SCIENCE TEACHER'S WORLD

For Teachers of Science
PLEASE ROUTE TO:

Teacher's edition of **SCIENCE WORLD** September 28, 1960
Edition 2

Reports from Curriculum Study Groups

This summer at three centers across the country, high school and college teachers worked together to produce experimental curricula in chemistry and biology.

At Tufts University, in Medford, Massachusetts, the Chemical Bonds Approach Course underwent a first revision after a one-year trial. At the same time, the Chemical Education Materials Study (CHEM Study) writing group convened at Harvey Mudd College, Claremont, California. This group produced an experimental course to be used for the first time this September.

While chemists worked on the coasts, the Biological Sciences Curriculum Study team of high school and college teachers met at Boulder, Colorado, and produced not one—but three experimental biology courses.

The three curriculum conferences are highlighted in reports prepared for *Science Teachers World* by conference participants.

Progress in Biological Sciences Curriculum Study

By Zacharia Subarsky
Bronx High School of Science

This summer, more than 60 high school teachers and research biologists in about equal numbers participated in a nine-week summer curriculum writing conference at Boulder, Colorado. Their efforts were directed toward improving high school biology in three areas: course outlines and texts, laboratory experiences, and special provisions for gifted students. The conference was sponsored by the American Institute of Biological Sciences on a grant of $738,000 from the National Science Foundation.

When the writing teams convened at Boulder, they were divided into three working groups, all under the leadership of Dr. Bentley Glass of the Johns Hopkins University and Dr. Arnold B. Grobman, Director of the Biological Sciences Curriculum Study. The groups produced three experimental versions of high school biology curricula designated "Green," "Yellow," and "Blue." The Green version is built around the natural interrelationships of living things. Dr. Marston Bates of the University of Michigan led the Green writing group.

The Yellow version—a developmental, organismal, and genetic approach—was produced by a team led by Dr. John Moore of Columbia University. This approach is closer to the traditional pattern in that the Yellow text starts with the amoeba and works

(Continued on page 6-T)

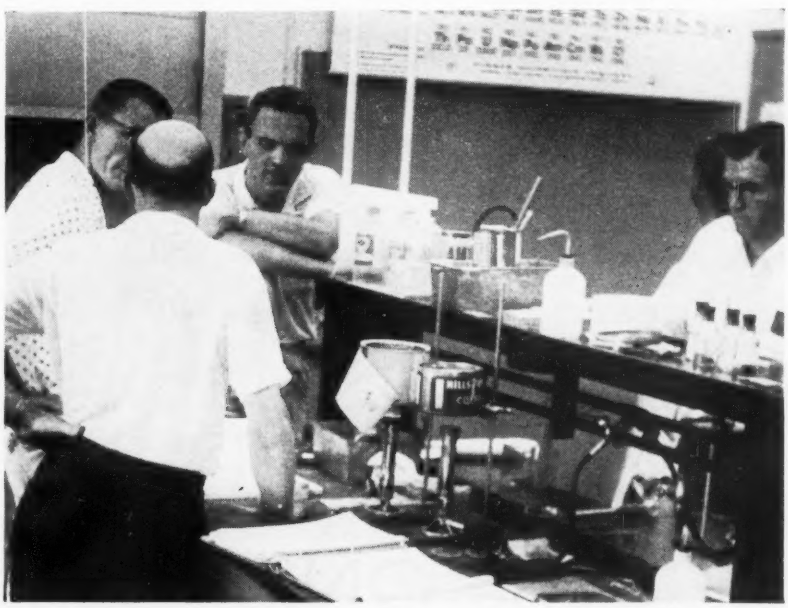

Photo by Keith MacNab

CHEM Study group prepared text materials built upon lab exercises. Part of group at work includes *(left to right)*: Laurence Martens, Oakland (Cal.) City College; Wilbert Bolliger, Ganesha H. S., Pomona, Cal.; J. A. Campbell, director of group, Harvey Mudd College, Claremont, Cal.; J. E. Davis, East H. S., Salt Lake City, Utah.

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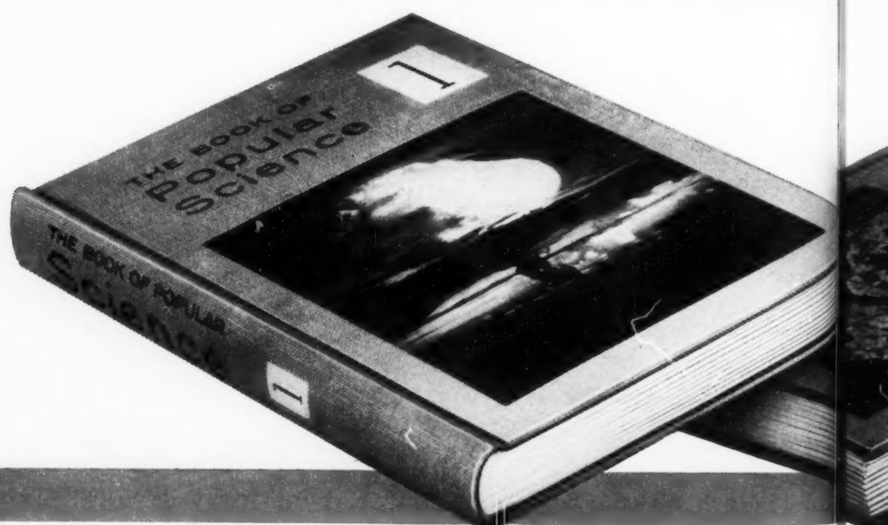

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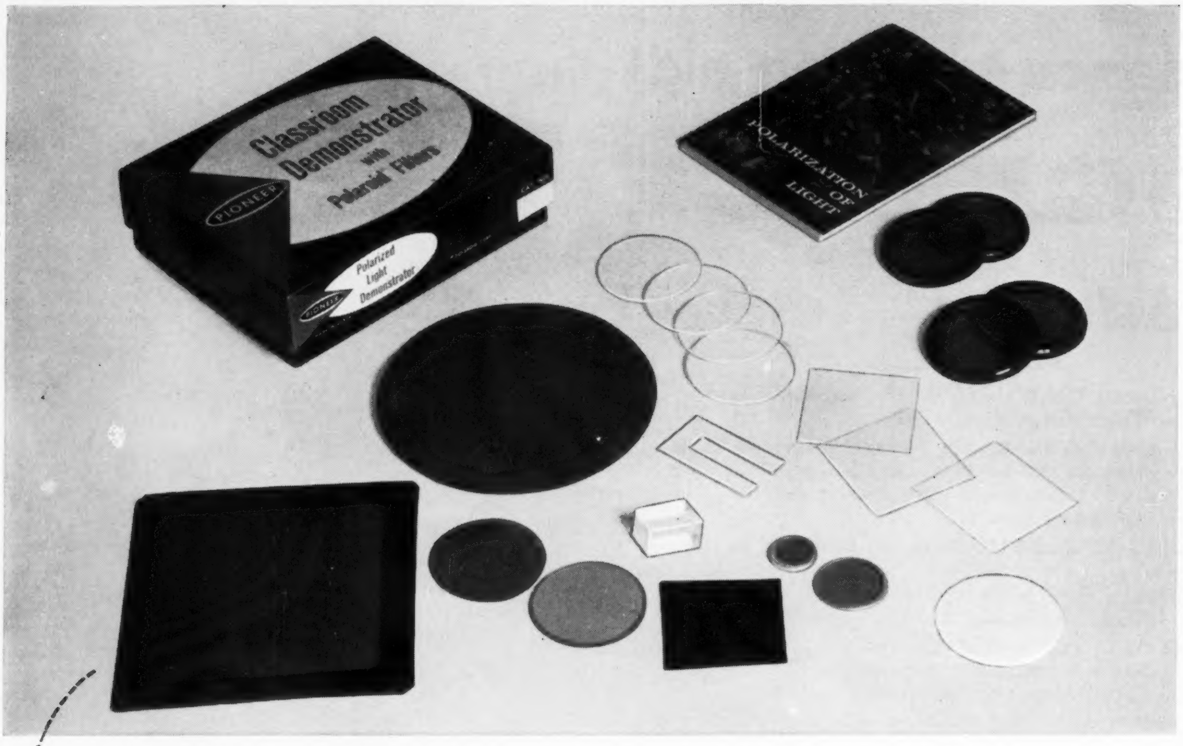

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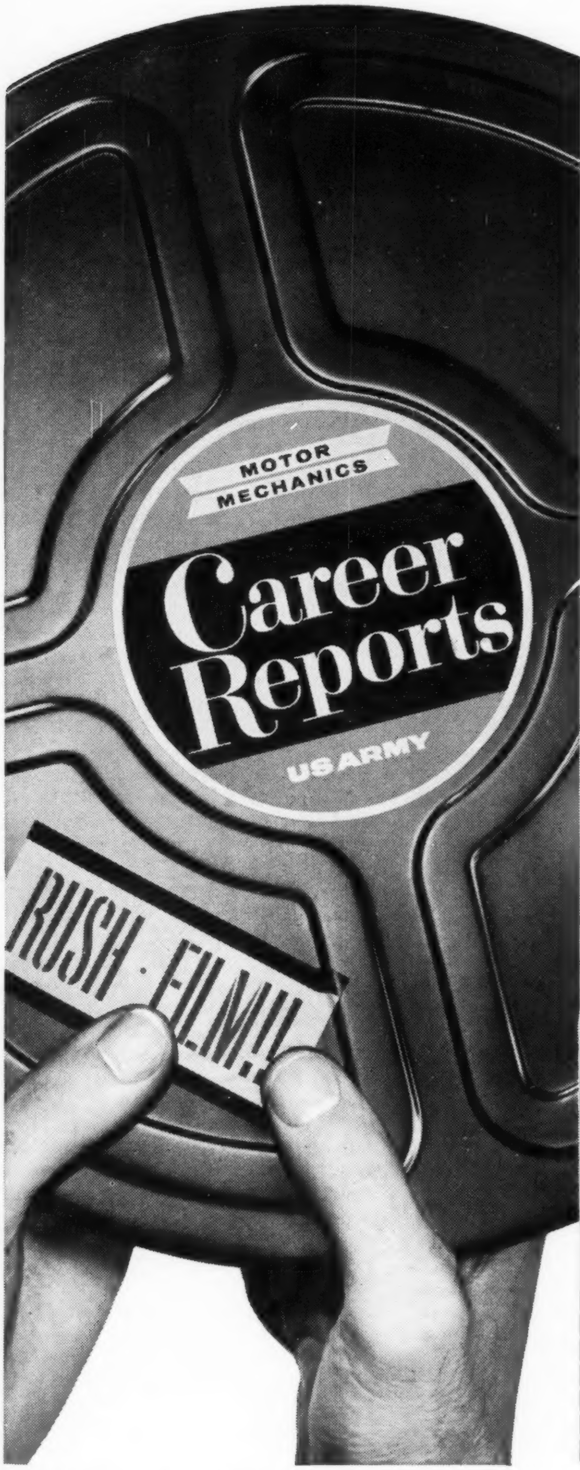

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Curriculum Study

(Continued from page 1-T)

upward to complex creatures, including man himself.

Dr. Ingrith Deyrup of Barnard College led the Blue version writers, who used the so-called "linear approach." The Blue text, starting with the organization of matter and concepts of energy as a point of departure, moves to ever higher levels of organization—cells, organs, organisms and populations. In all three versions, the texts are accompanied by teachers commentaries.

The materials produced this summer are tentative. During the coming school year, they will be tried out with biology classes in 105 representative high schools in 15 regional centers throughout the country. To this end, the teachers involved in the tryout were brought together in Boulder for a briefing session. On the basis of "feedback" from teachers using the first versions, the materials will be rewritten during the summer of 1961. After next summer's re-write, the materials will be tried out in a larger number of schools—as many as 5,000, the Institute hopes. A third re-write is now planned for the summer of 1962.

The schools participating in this year's trials are organized around 15 testing centers, each of which has a center leader and a center consultant. Throughout the school year, the participating teachers and consultants will meet weekly to discuss the program materials for the coming week and to assess their experience to date.

Laboratory Block Program

In addition to the three versions of the high school biology course, the conference launched another significant project—*the laboratory block program.* This is truly an innovation in high school biology teaching. The laboratory block consists of a six-week period during which laboratory work, reading, discussion, and field activities center around a major biological topic. The work progresses through a series of related laboratory experiments. Thus, the student is given laboratory experience in depth as he proceeds from simple laboratory exercises to more sophisticated approaches than are generally provided in the conventional high school biology laboratory.

Twelve such laboratory blocks are planned. Four have been completed and are to be given trial runs in eight schools. Those now ready are: 1. *Plant Growth and Development.* 2. *Microbes: Their Growth, Nutrition and Interaction,* 3. *Animal Growth and Development,* and 4. *Form and Function in Animals (Motion).*

To make special provisions for gifted students, the Biological Sciences Curriculum Study committee broadcast an invitation to research biologists for projects. More than 500 projects were submitted. A six-man team of teachers and researchers selected 100 of the projects to be edited and organized into research prospectuses for gifted students.

Each of the selections represents a research problem for which solutions are not yet available in the literature. In the form for presentation to the student, each prospectus includes some background information, the delineation of the problem, and a bibliography. The prospectuses will be made available to teachers for use with gifted students.

Research Problems for Students

The Biological Sciences Curriculum Study was organized in January 1959, under the auspices of the American Institute of Biological Sciences Education Committee. The director of the program, Dr. Arnold B. Grobman, on leave from the University of Florida, is now at the University of Colorado in Boulder.

CHEM Study

By J. A. Campbell
Harvey Mudd College

and Saul Geffner
Forest Hills High School

The Chemical Education Materials Study, or CHEM Study, was begun at the University of California early in 1960 under the chairmanship of Dr. Glenn T. Seaborg, Chancellor of the University of California at Berkeley. It is directed by Dr. J. Arthur Campbell, Chairman of the Department of Chemistry at Harvey Mudd College in Claremont, California.

The study recognizes the following problems that beset present high school courses in chemistry:

1. The average course of study content is generally outmoded, having undergone little or no change during the past half-century. The course content generally represents a multiplicity of unrelated ideas, requiring the student to display prodigious feats of memory to insure mastery and understanding.

2. Present courses of study have failed to keep abreast of modern thinking in chemistry. Such courses do not reflect the tremendous advances made in chemistry during the past two or three decades. Thus, much of what is being taught presently is either archaic or, what is even worse, incorrect. The student who continues his chemistry studies at college is required to unlearn considerable material before he can really go ahead.

3. The laboratory program in the high schools is, in most instances, no better than minimal. This difficulty stems from the nature of the laboratory experiments, the quality of the equipment used, and the unrealistic time allowance for such work.

To meet the challenge posed by these problems, the CHEM Study has undertaken an investigation of various techniques which might be used to make the study of high school chemistry more meaningful. With the advice of a steering committee, it was decided to prepare text material built upon laboratory exercises, all emphasizing the general theme that chemistry is an experimental science. To enhance the program further, it was decided to look into the possibility of producing appropriate films and writing monographs.

During the last two weeks in June and for the entire month of July, a group of contributors met at Harvey Mudd College to prepare the textbook and laboratory materials. This group of nine high school teachers and seven college teachers was directed by Dr. George C. Pimentel of the University of California at Berkeley. As a guide in the preparation of these materials, the writing group adopted the following principles:

1. Chemistry is an interesting and, to many, fascinating subject. But it should be studied thoroughly with understanding, rather than superficially.

2. The course should be built around modern chemical theory and develop a treatment which recognizes a few major unifying themes.

3. Wherever possible, the role of experimentation must be outlined and appropriately stressed.

4. To enhance his understanding, the student should spend at least 20 per cent of his time in the laboratory. The selection of laboratory materials should relate very closely to the text. The role of measurement should be stressed whenever and wherever possible.

A few chapter topics from the text listed below will reveal, to some extent, how items 1, 2, and 3 have been handled. The course begins with an experimental approach, the study of a common chemical system—the burning candle. Unlike the traditional courses in high school chemistry, topics such as the following have been developed to insure some real insight into the nature of chemical change:

1. Energy changes in chemical reactions.

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Curriculum Study

(Continued from page 6-T)

2. Rates of chemical reactions.
3. Equilibrium in chemical reactions.
4. The structure of atoms and molecules (from an elementary energy level viewpoint).
5. Periodicity of chemical properties and electronic structure.

The laboratory program was directed by Dr. Lloyd Malm of the University of Utah. Laboratory experiments were designed to supplement the text, emphasizing always the role of experimentation in the development of an idea. A study of the content of these experiments will reveal the extent to which this goal has been achieved.

The film program will, of course, require much more time for completion. It is expected, however, that considerable progress will be made in this direction during the coming year. The preparation of monographs will await revisions of the text and thus little can be done in this area during 1960-61. Mr. David Ridgway is in charge of film production.

The projected Chem Study course of study will be tried by 23 high schools in 1960-61. The 23 trial teachers spent the month of August at Harvey Mudd College discussing the course and trying out the materials. Most of this group, it is planned, will meet regularly during the school year to exchange experiences. The course materials will be tried out in average ability high school classes in chemistry.

A first revision is planned during the summer of 1961 on the basis of recommendations by the trial teachers. Some teacher-training institutes will also be held during the summer of 1961 to enable a larger number of teachers to study the revised materials and then use them during 1961-62.

Chemical Bonds Approach

By M. Kent Wilson
Tufts University

The Chemical Bond Approach Course (CBAC) for beginning chemistry students grew out of two conferences held by science educators in 1957 and 1958. The first of these, sponsored by the Weyerhaeuser Company, was held at Reed College, Portland, Oregon, in the summer of 1957. Some members of the 1957 group met again at Wesleyan University, Middletown, Conn., during the following summer. At that time, plans were made for a writing team to meet at Tufts University at Medford, Mass., in the summer of 1959. The writing team at Tufts produced the first draft of the Chemical Bonds Approach Course. The course, in form of text and laboratory manual, was used for the first time on an experimental basis in about a dozen high schools and colleges during the 1959-60 academic year.

This summer, four institutes, sponsored by the National Science Foundation, were held at Tufts for teachers interested in using this approach to the teaching of chemistry. A further grant from the NSF will enable a trial of the second version of the laboratory manual and text material to be made in about 70 schools. Roughly 6,000 students will be involved in this second trial year.

The Chemical Bonds Curriculum has the concept of chemical bonding as its central theme. Throughout the course, attention is focused upon the physical and chemical properties imparted to substances by the various types of chemical bonds. And, conversely, students are made aware of the possibility of inferring the type of bonding present in molecules from observations of their physical and chemical properties.

Chemists deal with aggregates of atoms. The properties of these aggregates are largely determined by the forces between atoms. In the Chemical Bond Approach, chemical bonds are divided into three model categories: covalent, ionic, and metallic. Since these prototype bonds seldom occur in nature, throughout the course considerable attention is also given to intermediate bond types, such as the polar covalent bond.

In the first version of the text, molecular geometry was introduced through the use of atomic and molecular orbitals, including the concepts of hybridization and resonance. This material is retained in modified form in the second version. However, it is now preceded by a discussion of mental model building and the electrostatic "charge cloud" model of atomic and molecular structure. The value of this model is that it can be based upon concepts close to the student's experience and does not invoke the artificial introduction of hybridization early in the course.

Throughout the course, emphasis is placed upon the usefulness and limitations of models of the physical world—a model is to be used as long as it produces useful insights and predictions, and as long as no better model is available. The various models of atomic and molecular structure are used interchangeably throughout the course. The choice of model depends upon which model yields the most satisfactory answer to the particular problem at hand.

Students are led toward the realization that chemical and physical properties are the result of the interplay of the ordering and disordering forces in the universe. Thus, considerable attention is given to the concept of free energy and its role in determining the course of chemical reactions. This approach leads to an understanding of the fundamental premises behind the concepts of energy and structure. We believe it should endow students with considerable predictive ability. Thus, descriptive material is introduced only where it amplifies the central theme. No attempt is made to list the preparation and properties of all the compounds usually encountered in a beginning chemistry course.

Laboratory work is central to any introductory chemistry course. Thus, considerable effort has gone into the design of laboratory experiments suitable to the unique format of the Chemical Bond Approach Course. Although detailed directions are kept to a minimum, extensive pre-laboratory discussions are provided for and are frequently used. Generally, students are encouraged to work out their own procedures other than following step-by-step instructions.

The Chemical Bonds Approach Course is still in its experimental stage. Last year's experience with about 800 students dictated considerable revision of the details of the first draft. It is anticipated that still further revision will result from the expanded trial during the 1960-61 school year. So far, the experience of students and teachers seems to bear out the expectation that CBAC, although somewhat demanding, is understandable and of real interest to the average student electing to take high school chemistry. An examination program is being developed to obtain more systematic information about achievement of students in this course.

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VIEW FROM MICHIGAN

High school teachers are vital in training scientists, according to University of Michigan scientists.

Dr. William E. Howard, astronomer, said "the first steps are often made in junior high. And if the student is not given good high school science courses and guidance, he may be lost to science. The teacher must keep the student's scientific interest alive in high school."

Physics Professor W. Wallace McCormick suggested it may be a mistake when "both high school and college physics rapidly survey a large number of the same topics."

Chemistry Professor Robert W. Parry emphasized the importance of communication skills. He said college students have great difficulty in these areas.

Using *Science World* in Your Teaching

The Earth's Gravity (pp. 6-9)

Physics Topics: Mass, Newton's law of gravitation, measurement of gravity, centrifugal force, acceleration of gravity, the pendulum, the metric system.

Earth Science Topic: The shape of the Earth.

Vocational Guidance: Geophysicist

About This Article

To most people the word *gal* is slang for girl; to a geophysicist, it is the name of the unit used to express the force of gravity. The article describes a variety of methods and instruments used to measure this force—calculations from acceleration of gravity, the pendulum, the invar gravimeter, and an unusual instrument made up of six pendulums that is usually used in submarines.

When gravity is measured with sufficient precision, some unsuspected phenomena are observed. For example, an Olympic broadjumper or javelin thrower performs better in Rome than he could in Helsinki. The difference in weight between an object at the Equator and the same object over the North Pole is greater than can be explained by the fact that the Earth is flattened at the poles. The article describes and explains a series of such phenomena and shows how, through gravimetry, the shape of the Earth and its structure can be explored. In the sixteenth century, Galileo measured gravity by dropping an object from a height. It is significant that today the U. S. Bureau of Standards does the same thing, but uses more refined methods of measuring the object's fall.

As supplementary reading in connection with related topics in the physics course (see list at the head of this review), the article serves two educational purposes: (1) it renders quantitative the concept of gravity, and (2) it shows how the measurement of gravity can be applied to problems of theoretical interest and practical importance.

Questions for Class Review, Reports, and Discussion

1. Where is the world station for standardizing the measurement of gravity? What is the value of gravity at that station? Explain deviations from that value (a) near the poles of the Earth, (b) near the Equator, (c) on top of a mountain.

2. Gravity may vary at different spots on the Earth—explain.

3. How does the rotation of the Earth affect the force of gravity?

4. How is a pendulum used to measure the force of gravity?

5. Describe the Vening-Meinesz gravity meter; how is it used?

6. Describe the invar gravimeter; state its advantages.

7. What is the most direct way of measuring gravity?

8. How much gravitational force is lost when an object is lifted from sea level to a height of 1,000 ft. above?

9. The force of gravity on an object over the ocean has been found to be about the same as the force over a land mass. Explain the statement.

10. "A plumb line will always hang perpendicular to a geoid." Define the word "geoid" and explain the statement.

Light and Life (pp. 10-13)

Biology Topics: Photoperiodism, photosynthesis, phototropism, plant hormones, animal hormones, animal migration, hibernation, life cycle of aphids.

Physics Topics: The light spectrum, absorption and reflection of light.

About This Article

The effects of light on life in some of its most delicate nuances are described in a way that tells not merely what is known, but how it was found out.

The author gives the history of studies in phototropism from the simple but elegant experiments of Darwin, through the classic investigations of P. Boysen-Jensen, Went, and Koegel, right up to the recent work of Labouriau and Galston at Yale. The story of these investigations moves along smoothly and is told with admirable lucidity. No less scholarly, detailed, smooth, and lucid is the story of photosynthesis research that follows, which includes the recent work of Arnon at Berkeley.

To continue this intellectual feast, the article reviews research studies in photoperiodicity in plants and animals. These research studies include force-flowering, nesting and migration, hibernation, and the life cycle of aphids.

The article is truly epic in its sweep and proportion. Students reading it will share vicariously in the excitement experienced by those engaged in biological research.

Topics for Reports and Class Discussion

1. Give the nationality and describe the discovery of each of the following scientists who were involved in research dealing with phototropism: (a) Charles Darwin, (b) P. Boysen-Jensen, (c) Frits Went, (d) Fritz Koegel, (e) Drs. Labouriau and Galston.

2. Describe the experimental work leading to the discovery of the "light reaction" and the "dark reaction" in photosynthesis.

3. Following are two pigments found in plants or animals. For each (a) state its role in the life of the organisms in which it is found, and (b) describe an experiment by which its role was discovered: chlorophyll, phytochrome.

4. Describe the experiment by which Dr. A. D. Lees caused aphids to lay eggs. What hypothesis does Dr. Lees advance to explain the results of his experiment?

Glue of Matter (pp. 14-17)

Physics Topics: Nucleons, atomic structure, cohesion, capillarity, crystal structure.

About This Article

The word "glue" refers to the forces that hold matter together. The article reviews experimental work with—and theoretical concepts of—two categories of forces: (1) those responsible for the mutual attraction of molecules that give rise to such phenomena as adhesion, cohesion, capillarity, etc.; and (2) those that hold together protons and protons, neutrons and neutrons, protons and neutrons in the nucleus of an atom. It is the forces of the second category that still baffle atomic physicists and are the subject of experimentation with nucleons shot out of accelerators. Factors that led Yukawa to postulate the existence of the meson are presented, and methods are described by which the existence of this particle was confirmed. Finally, the author describes experiments through which nuclear forces are currently being studied.

Topics for Class Reports and Discussion

1. An experiment to measure the attraction between molecules is described in this article. What difficulties were encountered in the performance of this experiment, and how was each difficulty overcome?

2. "All the forces with which we are familiar—electromagnetic, electrostatic, and gravitational—indicate that the particles in the atomic nucleus should fly apart from each other." Discuss this statement as applied to the atomic nucleus as we conceive of it at present.

(Continued on page 13-T)

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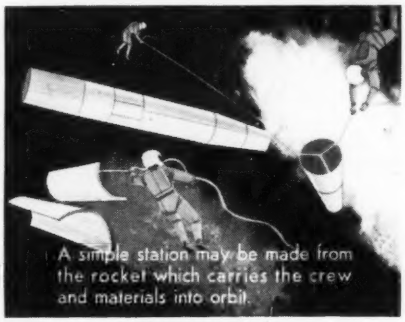

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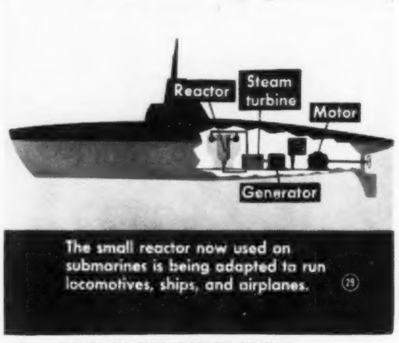

from SCIENCE FOR BETTER LIVING *described at right*

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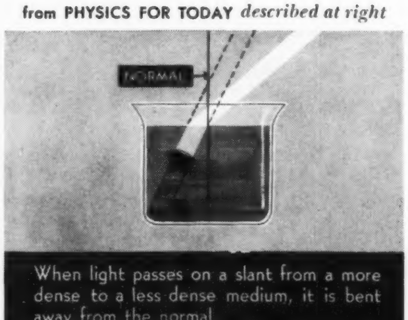

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Watson Davis

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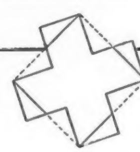
Dr. Donald G. Decker: Dean of Colorado State College of Education, Greeley; member, National Commission on Education in the Basic Sciences; past president of National Science Teachers Assn.

Data on additional members of the Editorial Board will appear in next month's Teacher Edition of Science World.

ANSWER TO PUZZLE IN STUDENT NEWS



Make four cuts as shown in drawing. Triangles cut from each arm of cross will fit into spaces between arms.

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SCIENCE WORLD

SEPT. 28, 1960 • VOL. 8 • NO. 2 • A SCHOLASTIC MAGAZINE • EDITION 2

Earth's Gravity

How It Is Measured

SEE PAGE 6

"The pressure of a gas varies inversely with its velocity"

Bernoulli's theorem: An 18th century physical law that helps make 20th century cars go.

Look at an automobile's carburetor. Seems complicated doesn't it? Actually the idea is quite simple and based on an old physical law. You can see the principle at work by laying a small piece of paper on a desk and blowing a stream of air across it. The paper will lift from the desk. The speed of the air moving across the paper creates a "vacuum"—less air pressure—and the greater air pressure beneath causes the paper to rise.

This is Bernoulli's law in action and a basis of the modern carburetor. Thanks to Daniel Bernoulli—and to the dedicated scientists and engineers at the Ford Research Laboratories who have found better ways to use his discovery—today, the Ford Family of Fine Cars carry bigger loads faster, farther, with less fuss, and do it on less gasoline than ever before.

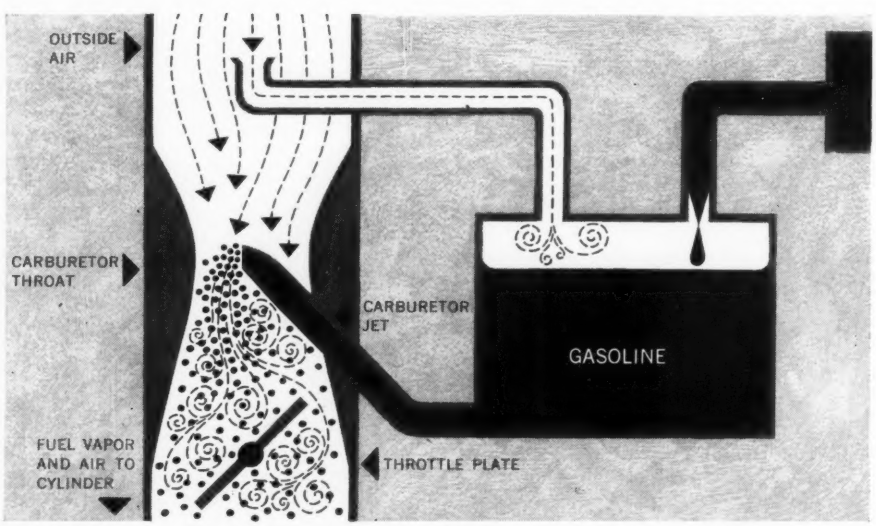
How the carburetor works in the Ford Family of Fine Cars:

1. Up-and-down stroke of the pistons creates a pumping action, drawing outside air into carburetor.

2. The carburetor throat speeds up the incoming air because of the smaller opening in the passage.

3. Since the air is moving faster at the throat, a "vacuum" is created (Bernoulli's law), and this draws droplets of gasoline into the carburetor through tiny jets. These droplets, or fuel vapor, are then mixed with the incoming air to form a balanced mixture that will explode in the cylinders to produce power.

FORD MOTOR COMPANY
The American Road, Dearborn, Michigan



FORD FAMILY OF FINE CARS

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Chip Martin
COLLEGE REPORTER
and
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HERE WE WORK WITH NAVAL ARCHITECTS TO IMPROVE THE DESIGN OF CABLE-LAYING SHIPS.
...SO CHIP WENT BACK TO HIS TYPEWRITER AND WROTE HIS STORY...
Experiments with undersea cables are part of a never-ending program of research by Bell scientists who are working today to bring us even better telephone service tomorrow.
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SCIENCE WORLD

SEPT. 28, 1960 • VOL. 8 • NO. 2 • A SCHOLASTIC MAGAZINE • EDITION 2

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C O N T E N T S

Features

Departments

Project Information Exchange

Science World offers a new service—the "Project Information Exchange."

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Keep your eye on the "Exchange" for a chance to help your fellow scientists.

NASA photo

EARTH'S

By SIMON DRESNER

AFTER four years of hard training since the Olympic Games were held in Melbourne, Australia, in 1956, the Olympic athletes tried in Rome this month to break previous records—by ten meters or one centimeter. Track and field men analyzed their sport to extract the last measure of performance from themselves. But one factor, generally overlooked, could be the cause of failure or success in setting new world's records: This factor is none other than the Earth's gravity.

Javelin throwers, high jumpers, and pole vaulters strain against the Earth's gravity to add a few centimeters to the previous record. But what if the Earth's gravity were to vary from place to place? Then an athlete using the same effort and skill would set different records in different places—determined by the pull of gravity. The pull of gravity is usually assumed to be the same everywhere on Earth. Actually, the pull of gravity is not the same everywhere.

The pull of gravity is strongest at the poles and weakest at the Equator. This difference is sufficient to suggest adjusting track and field records for different latitudes. For example, other things being equal, we should expect jumpers to jump higher and javelin throwers to hurl the javelin farther at the Rome Olympics (lat. 41.9) than they did in the 1952 games at Helsinki, Finland (lat. 60.2).

If we make corrections for the smaller pull of gravity at Rome, because of its location closer to the Equator, we can calculate that the world's javelin record (8,041 centimeters) would go 12.38 centimeters farther at Rome than at Helsinki; the hammer throw would go 11.27 centimeters farther for a new record at 6,416.27 centimeters—if they were hurled with the same velocity at both places.

Where a centimeter or more may make or break a world's record, this gravity variation makes necessary a significant correction. Some day these corrections may be made by Olympic officials. A glance at the table of athletic records (*p.* 8) shows that the pull of gravity varies by about five parts in a thousand from the poles to the Equator.

The pull of gravity as measured over the Earth's surface varies from a low of 977 gals to a high of 983 gals. A gal is a unit of gravity, named in honor of Galileo, who experimented with gravity by dropping cannon balls from the leaning tower of Pisa.

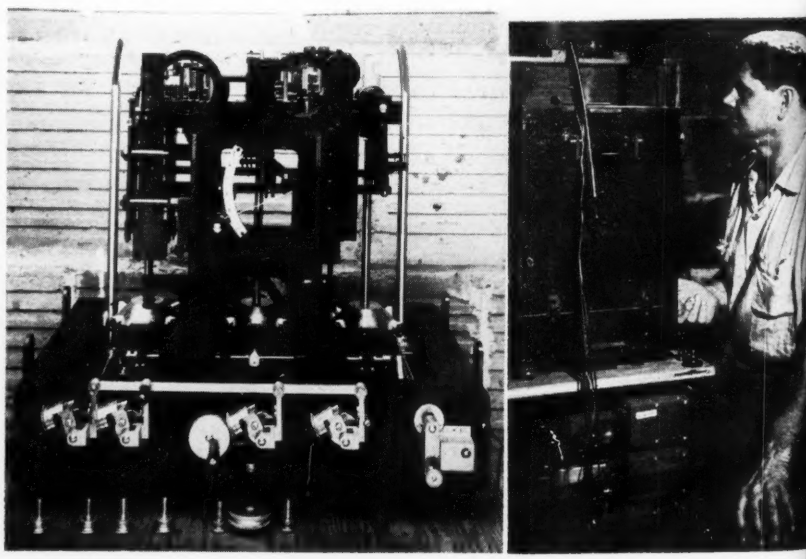
Measure of Gravity

Galileo found by experiment, or perhaps by simple reasoning, that the force of gravity accelerates all free-falling objects at the same rate. This acceleration is constant for all objects whether heavy or light, and is a direct measure of the force of gravity.

The gal unit expresses the force of gravity in terms of the acceleration of one centimeter per second, per second, written 1 cm/sec.^{2}.

Most gravity measurements are compared to those taken at the world-standard station, the observatory at Potsdam, Germany. Painstaking measurements carried out there have established the value of gravity as 981.274 gals. This means that at Potsdam a falling body would increase in speed at the rate of 981.274 centimeters per second every second.

However, at the North Pole this figure would be slightly higher, and at the Equator slightly lower. To explain this variation in the force of gravity, we must refer to Newton's Law of Universal Gravitation. The law states that the gravitational force between two bodies varies according to the product of the masses divided by the square of the distance between the two masses, measured from the center of each mass. The farther apart the masses are, the less



Six-pendulum instrument *(above)* measures gravity over the oceans, and cancels out motion of ship. Used in submarines submerged to depths where effect of waves is not

GRAVITY—HOW IT IS MEASURED

By measuring this force, scientists discover new clues to the Earth's structure

the gravitational pull on each other. Also, the greater the mass of the bodies, the greater the attraction between them.

In a ball of matter such as the Earth, the gravitational pull behaves as if the entire mass of the Earth were concentrated at its center. Thus, some variations in the force of gravity are due to the irregular shape of the Earth. One irregularity is the flattening at the poles. Scientists have found that the distance to the center of the Earth is about thirteen miles less at the poles than at the Equator. This is a difference of only one third of one per cent in the Earth's 4,000-mile radius. But according to Newton's law, the pull of gravity at the poles would be greater, since the location is closer to the center of the Earth. Measurements of the orbit of Vanguard I, launched in 1958 and still transmitting information, confirm the irregular shape of the Earth.

If the surface of the Earth were smooth, it would be comparatively simple to analyze gravity measurements. But the Earth's surface is irregular, broken by mountains, plains, and oceans. All these masses of matter affect the pull of gravity, depending on their density and their altitude, according to Newton's law. Also, the interior of the Earth is composed of various materials in concentric layers, like a golf ball. The density of these materials varies from place to place. These masses of buried matter exert varying gravitational force on objects at the surface. For example, a layer of heavy granite underground would be responsible for more gravitational force than a layer of light porous rock or clay underground.

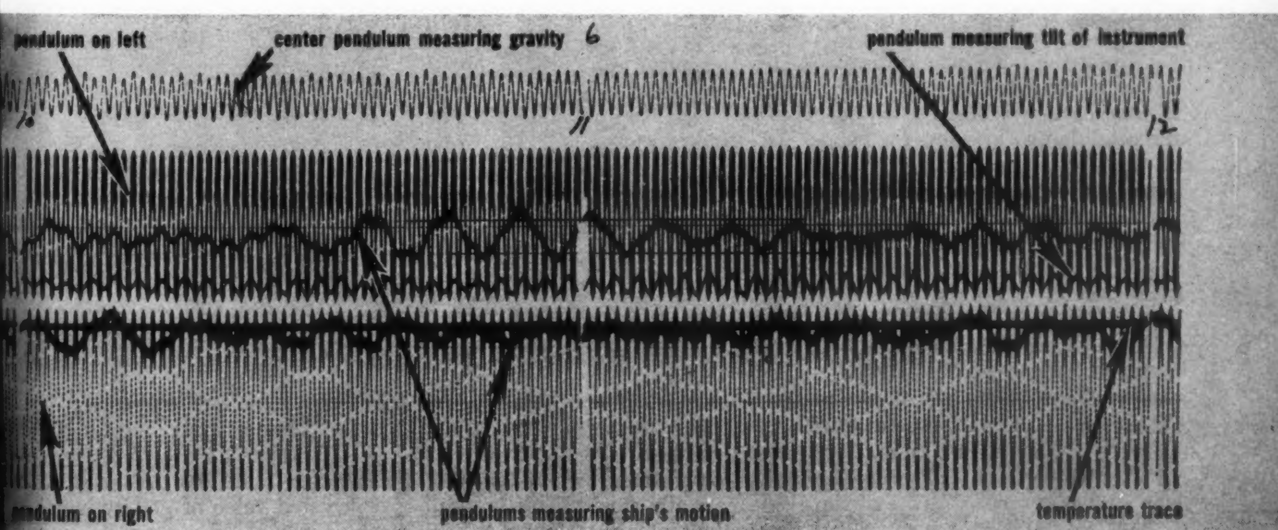
Effect of Rotation

Slight variations in gravity also are caused by the gravitational attraction of the sun and moon, and by the changing depth and curvature of the ocean surface caused by the tides.

Another small but important variation in the force of the Earth's gravity is caused by the rotation of the Earth. Objects at the surface of our spinning Earth tend to fly off into space due to centrifugal force, for objects moving in circular paths tend to move away from the center of their motion. Thus the direction of force at the surface of the Earth is away from the Earth's axis and has the effect of opposing the Earth's gravity (except at the poles). Scientists suppose that if all gravitational attraction should suddenly cease, all objects on the Earth's surface would be expelled into space.

Centrifugal force depends on the distance of the object from the Earth's axis of rotation. The farther an object lies from the axis, as at the Equator, the stronger is the centrifugal force. Centrifugal force vanishes altogether on the Earth's axis at the poles.

This means that at the Earth's Equator the relatively stronger centrifugal force would make it seem as if the force of gravity were weaker.



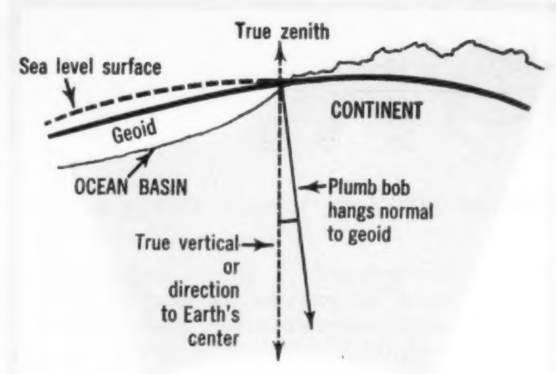
Photos from Lamont Geological Observatory

felt, the device is being adjusted by Dr. F. Worzel of Lamont Geological Observatory, N. Y. Motion of pendulums (six in all) is recorded by light beams on photographic strip. Center pendulum measures gravity; others record motion of submarine.

Latitude (Degrees)	Correction Factor	Javelin Throw 8.041 Centimeters	Broad Jump 813 Centimeters	Shot Put 1.854 Centimeters
90 (Pole)	+.003043	+24.47	+2.47	+5.64
70	.002463	19.80	2.00	4.57
60.2 (Helsinki)	.001760	14.15	1.43	3.26
52.3 (Berlin)	.001119	9.00	.91	2.07
50	.000901	7.24	.73	1.67
48.8 (Paris)	.000796	6.40	.65	1.48
41.9 (Rome)	.000217	1.77	.18	.41
40 (Columbus)	0	0	0	0
37.7 (Melbourne)	−.000199	−1.60	−.16	−.37
34.1 (Los Angeles)	.000514	4.13	.42	.95
20	.001536	12.35	1.25	2.85
10	.001986	15.97	1.61	3.68
0 (Equator)	.002143	17.23	1.74	3.97

Science World graphic

Corrections for Olympic records established in different cities is suggested by fact that force of gravity varies with latitude.



Science World graphic

Curve perpendicular to force of gravity is called geoid. Geoid differs from sea-level surface due to uneven mass of the Earth.

At the poles, the absence of centrifugal force would make the force of gravity seem stronger. Thus objects would weigh more at the poles than at the Equator.

In principle, the measurement of gravity is a simple matter. It can be done with an ordinary pendulum. When a pendulum is raised from its rest position and released, gravity pulls it downward. It continues upward again, rising against gravity, because of inertia (resistance to change in motion). Eventually the rising pendulum is slowed by the pull of gravity, and drawn down again for another swing.

If the length of the pendulum is known, the time taken by one back-and-forth swing of the pendulum gives us a measure of the force of gravity at the place where the pendulum is located. The time required for one back-and-forth oscillation of the pendulum is known as the *period* of the pendulum. The period of a pendulum remains almost constant when its swings are short. Theoretically, only a change in the pull of gravity can affect the period of a pendulum (oscillating over a short distance in a perfect environment).

To make a pendulum sensitive to slight changes in gravity, it must be constructed so that it swings with almost no friction. The swinging weight is attached to knife edges which pivot on flat, polished agate stones. This is the same type of support used in delicate chemical balances. A very accurate timer is used to measure the time taken for each swing of the pendulum.

Gravity pendulums such as the one at Potsdam can measure the strength of the Earth's gravity to one part in 10 million. Such precise measurements are achieved by timing several thousand swings. This precision is necessary because even large variations in the structure of the Earth's crust create only slight variations in the pull of gravity. To measure variations in gravity all over the surface of the Earth many gravity measurements must be taken at numerous locations.

Measuring Gravity at Sea

Measuring gravity aboard a ship at sea poses a special problem for a pendulum gravity meter. To solve this problem, an ingenious Dutch geophysicist, F. A. Vening-Meinesz, has devised a gravity pendulum apparatus which cancels out the motion of the ship and computes only the effects of gravity. This device uses six pendulums. By their motion, three of the pendulums eliminate the effect of irregular movements of the submarine, and yield a measure of gravity. Data for additional corrections is provided by the other three pendulums.

This gravity apparatus can be used only in a submerged submarine, where there are no violent waves. The geophysicist and his pendulum instrument are sometimes placed in the compartment where explosives are normally stored. This is located near the center of motion of the ship, where the ship's motion is at a minimum.

The submarine travels at a speed of about three knots, to maintain minimum roll and pitch. It takes about 25 minutes to make a single gravity reading. During this time the pendulum swings back and forth about once a second. To take a number of gravity measurements over a specific area, a geophysicist may have to spend several working months in the cramped quarters of a submarine.

A more common type of gravity measuring instrument, the gravimeter, is no more than a supersensitive spring scale. The Earth's pull is measured by the stretching of a thin wire of silica or invar (a nickel-steel alloy), from which is suspended a small weight. The position of the weight is viewed against a scale through a microscope. The gravimeter is small, weighs only a few pounds, and can be carried anywhere to make rapid measurements in three to five minutes.

The gravimeter can measure no more than the difference in gravity between one spot on Earth and another. To obtain an absolute value, measurements must be referred to a base station, such as the pendulum at Potsdam.

In using a gravimeter to study the structure of the Earth's crust, only variations of the Earth's gravity from place to place need to be calculated. After a gravity measurement is corrected, the difference between the corrected value and the theoretically calculated value of gravity is called an *anomaly*. These anomalies enable geophysicists to obtain a precise picture of the Earth's crust.

For example, a gravity measurement taken on top of a mountain in

the Alps of Switzerland, will differ from the theoretical or average value of gravity for that latitude. The top of the mountain is more than the average distance from the center of the Earth, so a correction must be made for altitude. This correction is about 9.5 thousandths of a gal for every 100 feet of elevation above sea level.

At one time it was supposed that the extra mass of a mountain should increase the pull of gravity, even after a correction for altitude. It also was thought that over the ocean, the relative lightness of water should yield decreased gravity measurements.

Oddly enough, the force of gravity at sea is about the same as that on land. Geologists have concluded that this equal pull may involve subcrustal rocks (those beneath the Earth's crust). These dense subcrustal rocks are closer to the surface of the Earth under the oceans than they are under the continents. Because of their density and closeness to the surface, the subcrustal rocks at sea exert a stronger gravitational pull. This explanation is called the theory of *isostatic equilibrium*.

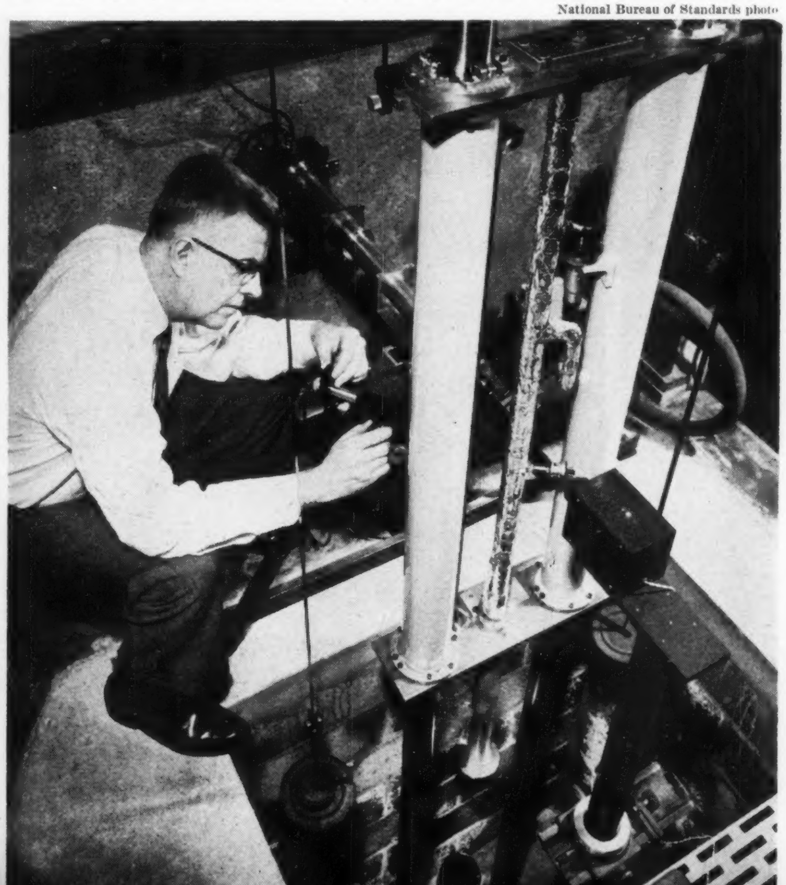
World wide measurements of gravity anomalies may soon help us to compute the Earth's actual shape. The profile scientists are trying to describe is not the ground surface, because this rises and falls irregularly over the sea floor and the continents. If we took gravity readings all over the Earth and corrected them to sea level, we would have a picture of the Earth according to its mass distribution. This profile is called the *geoid*.

In theory, if canals of water at sea level could cross the continents, the water level in the canals would follow the surface of the geoid. The geoid is like the surface of a battered orange, with a generally ellipsoidal shape. The "bumps" in the surface are caused by local variations in mass.

The shape of the geoid, when it is found, will enable scientists to determine precisely where up and down are. At present, surveyors and astronomers determine the vertical with a plumb line (simply a weight at the end of a string). The plumb line points in the direction of the force of gravity. The plumb line does not necessarily point to the Earth's geometric center. The plumb line will always hang perpendicular to the surface of the geoid, since the geoid is the shape of the Earth according to the pull of gravity. Knowing the shape of the geoid all over the Earth will make possible more accurate scientific measurements, such as the precise radius of the Earth.

Free-falling quartz rod is used to determine force of gravity at National Bureau of Standards. Rod is inside foil-covered tube between white cylinders. Joined top and bottom, these make up carriage, which drops freely. Spring gives carriage initial "kick," so that quartz rod floats away from carriage during free fall. Descent is timed by light beams interrupted by precisely cut slots in the falling quartz rod.

National Bureau of Standards photo



Measure Speed of Fall

Perhaps the most direct way of measuring gravity is according to the definition: Drop an object and see how long it takes for it to fall a certain distance. From this the acceleration of gravity can be calculated. Until recently this experiment could not be performed to the required accuracy. Measuring the time and distance of fall must be done in a fraction of a second. (In contrast, measuring the swings of a pendulum can be carried out over an hour or longer.)

The United States Bureau of Standards is presently measuring gravity by dropping a quartz bar and measuring the speed with which it falls. To time the bar's fall, a light beam and photoelectric cells are used. As the bar drops, the light beam passes through precisely cut slots in the bar and signals the photoelectric cells. These signals are precisely timed and measure how fast the quartz bar is falling, so that the acceleration due to gravity is calculated.

This gravity experiment, now in progress, is based on the free-fall principle. It is not very different from the one in which Galileo dropped his cannon balls from the leaning tower of Pisa, almost four centuries ago. But measuring one of the fundamental quantities in nature to an accuracy of one part in many millions is truly one of the remarkable achievements of modern science.

Light and Life

By WILLIAM RICHARDS

The seven colors of visible light power all the processes of life

ALL the processes of life—growth, development, and decay—are powered by the energy of sunlight. You would not be wrong if you said, "On Earth, life runs on sunlight."

There are many ways in which the sun's energy powers the processes of life. All these ways are not yet understood. But explanations are evolving, as the work of one scientist becomes the springboard for another's research.

The chain of research started in 1880, when Charles Darwin, the great British naturalist, carried out a series of experiments to find out why plants bend toward the light—the phenomenon we call *phototropism*.

Darwin placed tiny, black-painted glass tubes on the growing tips of oat seedlings. He found that the capped seedlings did not bend toward the light. He also placed blackened glass collars just below the tips of other seedlings. The collared plants did bend.

Darwin concluded that in some way the growing tip influences plants to bend toward the light.

About 30 years later a Danish scientist, P. Boysen-Jensen, carried Darwin's experiments a step farther and added to the chain. He made horizontal incisions in oat seedlings, just below the growing tip. Into each incision he inserted a thin sliver of mica. He made this assumption: the sliver of mica would block off whatever it was that influenced the bending of the plant and would keep it from moving down the stalk.

In one group of seedlings, the sliver was inserted on the side facing the light source. In another group, the sliver was placed on the shady side, away from the light source. What happened? The seedlings with slivers on the light side bent toward the light. The others grew straight.

Boysen-Jensen concluded that whatever acts on plant tissue to

Bending of plant toward light is shown in fruiting mold. Multiple photo was made with exposures at 5-minute intervals.

Here fruiting mold was put on turntable which revolved once every 2 hours near fixed light source. Stalk grew in spiral.

Photos taken by Dr. Max Delbrueck, California Institute of Technology

cause bending, exerts its influence on the shady side of the growing tip, rather than on the light side.

Examination with the microscope revealed that cells on the shady side grew more rapidly than those on the sunny side, causing the plant to bend in response to mechanical pressure.

About two decades ago, a Dutch scientist, Frits Went, performed a series of experiments that established the existence of a growth-promoting substance.

In the first experiment, Dr. Went sliced off the growing tips of seedlings. He found that growth stopped in the decapitated seedlings. When the tip was replaced, growth was resumed.

Dr. Went next placed the decapitated tips on little blocks of gelatin. He let them stand there for one to four hours. Then the gelatin blocks were placed on the decapitated seedlings. He also placed untreated gelatin blocks on seedlings as controls. Growth resumed in those seedlings capped with treated gelatin, but not in those capped with plain gelatin. From this he concluded that there was a growth-promoting substance in the tip that had been absorbed by the gelatin block.

In his last series of experiments, Dr. Went prepared gelatin blocks in the same way. But when he put them back on the stalks he covered only half the tip. The stalks grew faster on the covered side. The pressure of the growing cells bent the stalk away from the growing side and toward the light side.

Auxin and Bending

Now here was a problem: What causes plants to bend? Is more of the growth promoting substance produced on the shady side? Or does sunlight have the effect of destroying the growth-promoting substance on the side toward the sun?

In 1934 another Dutch scientist, Fritz Koegl of the University of Utrecht, identified and studied the growth-promoting substance. It was auxenolic acid—auxin, for short.

Thus the work Darwin started 50 years before led to an important and entirely unexpected result—the discovery of plant growth regulators. But the connection between auxin and bending was not yet clear. The question—why do plants bend toward the light—still remained unanswered. Is there more of the auxin on the shady side of the plant—or does the light destroy auxin on the side toward the sun?

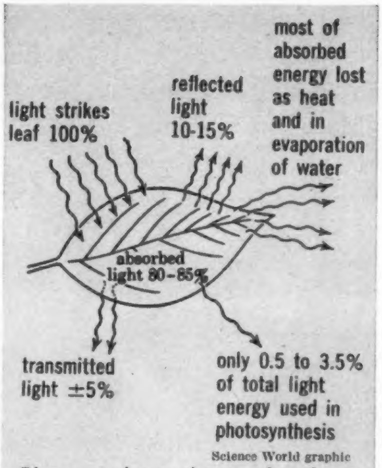
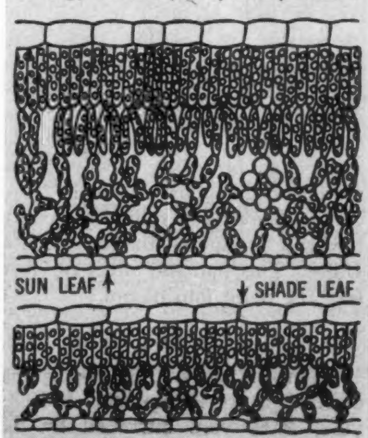


Diagram above shows what happens to light that strikes a leaf. Note that leaf does not use sun's energy efficiently for photosynthesis.



Above are cross sections showing leaf grown in the sun and one of same species grown in shade. What caused more growth in the sun leaf?

Another clue was found within the past year by two scientists at Yale University, Dr. L. G. Labouriau and Dr. Robert Galston. They found that greenish-yellow pigments, called flavins, were present in the growing tips of plants. They found that the light absorbed by flavins stimulates phototropism. Thus, the most recent hypothesis is that light energy absorbed by flavins may play a part in destroying auxin. On the shady side the pigments absorb less light. Thus more of the auxin remains to stimulate cell growth, with resulting pressure and bending.

When plants turn toward the sun, their leaves absorb more of the sun's energy. Phototropism thus permits leaves to receive a maximum amount of sunlight for photosynthesis.

Of all the chemical reactions that take place on Earth, scientists believe that photosynthesis is by far the most important. How can such a claim be justified?

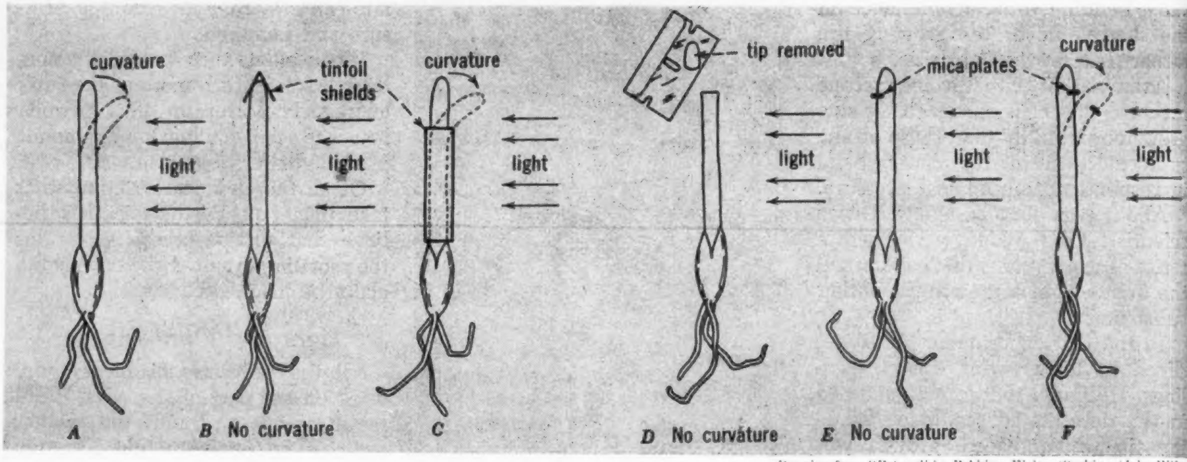
Light and Plant Energy

All the processes of life require work on the part of the cells. Work requires energy, and the plant's source of energy is sunlight. Through the energy of sunlight, sugar is formed in the leaves of plants when carbon dioxide (CO_2) and the hydrogen of water (H_2O) are combined into a compound that has the formula $C_6H_{12}O_6$. The sugar and starch—carbohydrate—produced by the green plant provide it with a source of energy. In turn, the sugar and starch produced by the plant are the source of energy for all living things.

Some of the light energy used by the plant in making carbohydrates is stored in the carbohydrates themselves as potential chemical energy. (You can see the reverse of the process when sugar is burned. The stored chemical energy is released as light and heat energy.) When plants and animals use carbohydrates in their bodies, the carbohydrate molecules are broken apart into carbon dioxide and water. The potential energy is then released.

Scientists still do not fully understand how photosynthesis takes place. However, some of the steps in the process have been worked out in the laboratory. Only one of the steps involves light. And here the green pigment, chlorophyll, plays its part.

A clue to the role of light in this reaction was discovered by Dr. C. B. van Niel of the Hopkins Marine Station of Stanford University in California. In his experiments, Dr. van Niel used bacteria that require hydrogen sulfide—rotten egg gas (H_2S)—to perform photosynthesis. He discovered that these bacteria released sulfur in the process. Summing up his experiments, Dr. van Niel theorized that the function of light



Drawing from "Botany" by Robbins, Weier, Stocking (John Wiley)

Early experiments showed that on shady side of oat seedling tip is a substance that causes seedling to bend toward light.

energy is to separate hydrogen from its compounds, so that it can combine with carbon and oxygen to form sugar.

In 1955 Dr. Daniel R. Arnon of the University of California at Berkeley isolated chlorophyll from green cells and experimented with photosynthesis in the laboratory. He identified two stages in photosynthesis. In stage one, known as the "light phase," light energy is trapped, water is decomposed, and hydrogen held. In stage two, known as the "dark phase," energy is released for building new molecules. Dr. Arnon found that stage two can take place in the absence of light.

Last June—after four years of research—Dr. Robert Burns Woodward of Harvard University produced about six hundred-thousandths of an ounce of chlorophyll in his laboratory. The duplication of photosynthesis in a test tube is still a long way off. But knowledge of the chemical structure of chlorophyll will lead to a better understanding of this highly complex process.

There is yet another response of plants to light that scientists now are investigating. For centuries man has known that plants have seasonal responses. Some bloom in the cool short days of spring—others in summer. Some plants bloom at night—while others prefer the midday sun. Recently we have begun to understand why this phenomenon, called *photoperiodism*, occurs.

About 20 years ago, nurserymen found through trial and error that flowers could be made to bloom out of season by shading them with cloth for part of each day. This was valuable information for commercial flower growers. But nobody understood why the event took place. It seemed to botanists, however, that somehow the plant was able to record a decrease in sunlight, a condition that resembled the approach of winter. This had the effect of "forcing" the plant into bloom.

Clue in Red Light

Scientists at the U.S. Department of Agriculture laboratories at Beltsville, Md., were intrigued by this mystery. They set out to hunt down the clues. One of the scientists at Beltsville, Dr. Sterling B. Hendricks, first exposed a variety of plants to all the colors of the spectrum. Most of the colors yielded no clues. But when the plants were exposed to red light the effect was exciting.

Even a 30-second flash of red light during a 14-hour period of darkness altered the growth cycle of the experimental plants. Suspecting that red light held the key to the mystery, the Beltsville scientists began to search for a pigment sensitive to red light.

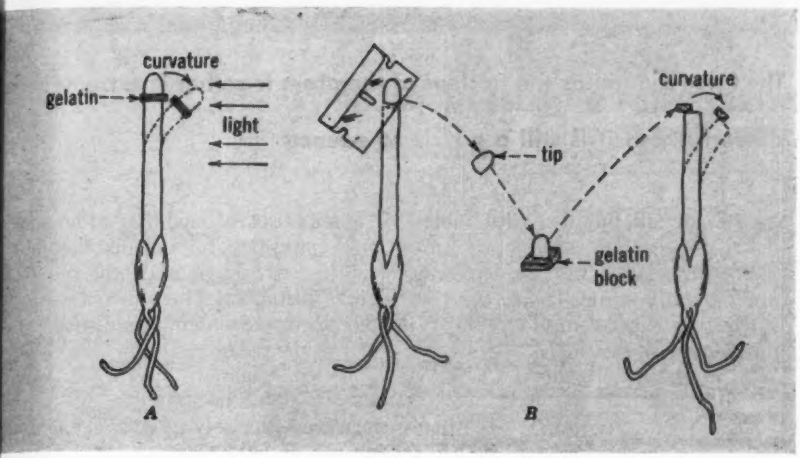
They found the tell-tale pigment in bean seedlings. In a given amount of juice from bean seedlings, the pigment makes up only one part in a million. The pigment changes when excited by red light. As long as the red light lasts, the change is in effect. When the source of red light is removed, the pigment slowly changes back. It takes 12 hours for the pigment to complete this cycle.

Now what does all this have to do with plants growing in sunlight? Morning sun is rich in red light. When the rays of the morning sun fall on a plant, the pigment undergoes a change which lasts until sundown. Scientists hypothesize that in some way the length of day is chemically "recorded" in the cells of plants.

To explore their findings, the scientists at Beltsville exposed plants to red light at all hours. What happened? Plants were made to bloom months ahead of time, or their bloom was delayed. Pine trees four years old, for example, have been kept down to a height of eight inches. How? By exposing them to very short periods of red light which signaled "winter"—no time for growth.

Scientists at Beltsville are still working with this pigment, named only during the past year. Dr. Sterling B. Hendricks told *Science World* the pigment has been given the name phytochrome (from the Greek words for plant and color). Dr. Hendricks explained that the pigment has been found in two forms—one active, the other passive. Exposure to light causes the active pigment to become passive. It retains its passive form during the hours of light, and is converted back to the active form during the dark hours.

Phytochrome has not yet been isolated in pure form. Most samples now contain 99 per cent of impurities. In spite of having so little of the



Drawing from "Botany" by Robbins, Weier, Stocking (John Wiley)

Later experiments showed growth-promoting substance is produced on shady side.

pure substance for experimentation, Dr. Hendricks pointed out, it is known to be a protein pigment soluble in water. Its color, apparently, is derived from a part of the protein molecule.

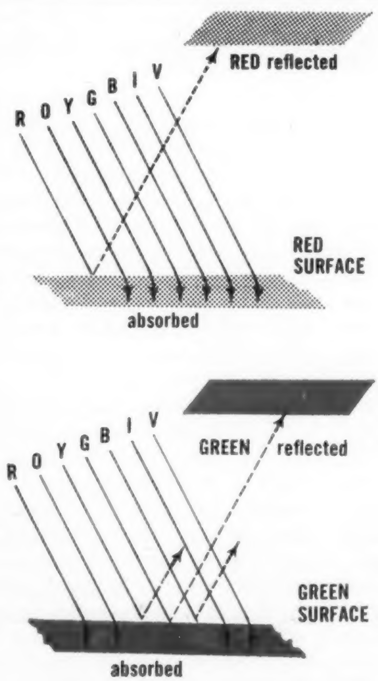
Describing his work, Dr. Hendricks said, "It's as if we had been hitting a carburetor with a hammer for years to adjust it. Discovering this pigment is like learning that a screw on the bottom of the carburetor is what regulates it."

Animals also show photoperiodism. Birds respond to increased levels of sunlight. Scientists believe that the nesting and migration of birds are responses to changes in the length of day, rather than to changes in temperature.

Scientists hypothesize that in animals chemical substances are involved in the transmission of photoperiod information. Dr. A. D. Lees of Cambridge University in England believes some of these substances may be hormones—chemicals that regulate the body. He has been investigating the life cycles of a species of aphid that is native to England. Aphids, commonly known as plant lice, suck the sugar rich juices from leaves and roots. The aphid Dr. Lees has been investigating produces several generations of live young throughout the summer. These are all females. At the end of summer, when days grow shorter, a generation of males and females is produced. These mate and the female now produces eggs. These eggs do not hatch until spring. At that time they give rise to a new generation of live bearing females to start the cycle again.

Dr. Lees found that as long as he kept the aphids under long photo periods (16 hours of light), they continued to reproduce live females indefinitely. When he shortened the photo period to 12 hours, the aphids produced eggs. Dr. Lees believes that this light response may be caused by hormones in the insect that are sensitive to light.

Thus the light of the sun is the source of energy for all living things. And man, a creature of the sun, is striving to understand how the sun's energy affects the processes of life.



WHAT IS LIGHT?

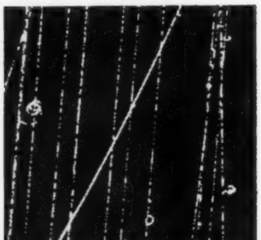
Light is a form of radiant energy. So is heat. So, too, are radio waves and X rays. All the forms of radiated energy are transmitted —or, as scientists say, propagated—in the form of waves.

If you have ever seen a beam of visible light passed through a glass prism, you know that light can be separated into seven bands of color. Each has a different wave length. In order of decreasing wave length, these are red, orange, yellow, green, blue, indigo, and violet. Violet has the highest energy—red the least energy.

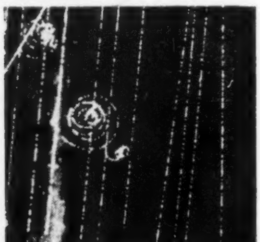
How does light energy affect matter? Nearly all molecules vibrate constantly at any temperature above absolute zero. When any material is heated its molecules vibrate more rapidly. The molecules are excited. Light, too, excites molecules to greater motion. Some excited molecules absorb certain wave lengths of light and reflect others. This reflection and absorption produces color in materials composed of such molecules. These materials are pigments. A pigment that appears red absorbs high energy wave lengths at the violet end of the spectrum of visible light. It reflects the red and near-red energy waves. Pigments are involved in many of the biological effects of light.

For example, in sea water light does not penetrate much below 600 feet. The only light that does reach such a depth is high energy blue light. Thus, at that level the only plants are the red algae. The red pigment of these plants efficiently absorbs the blue light.

THE



"GLUE"



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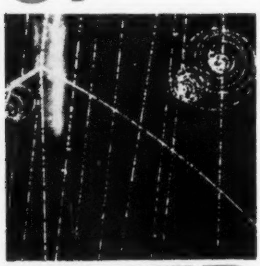

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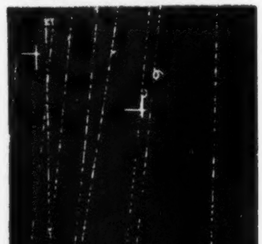


Brookhaven National Laboratory

By MICHAEL DADIN

The force that holds the nucleus of the atom together is extremely powerful, but it is still a puzzle to science

WE are all familiar with molecules and atoms—and the fundamental particles such as electrons, protons and neutrons. These are the "things" of which atoms are made. But how do all the molecules, atoms, and particles "stick" together to become larger chunks of matter. In other words, what are the forces that make up the "glue" of matter?

Part of the answer to this question was suggested by a remarkable experiment performed by Russian scientists at the Academy of Sciences in Moscow. The scientists wanted to measure the forces of attraction between molecules—the smallest units of matter in its common, everyday form. They were not concerned with chemical attractions, or valence bonds, which link atoms chemically in a compound. They wanted to measure the forces that draw together the molecules of solids and liquids, and to a small extent, gases. For example, oxygen atoms in a molecule of water do not attract each other, but every molecule in a sample of water attracts every other water molecule near it. These forces are responsible for surface tension, capillary action, and other properties of liquids.

How does one go about measuring the attraction between molecules? Evidence indicated that the force to be measured was very small—as little as one-thousandth of a gram. In itself, this measurement normally would not be too difficult. But so slight a force between molecules shows up only when two bodies are extremely close together—within a few ten-thousandths of a millimeter, or about one thousandth of the thickness of a human hair. In addition, the attracting force tends to increase suddenly when the molecules are brought so close together.

In the experiment, the attraction measured was that between a polished quartz plate and a polished quartz lens brought close to the surface of the plate. The quartz plate was attached to the arm of a microbalance, while the lens was fixed. The scientists realized that no human hand could possibly balance the delicate forces and regulate the microscopic distances. Therefore, a sensitive electronic system was devised to control the balance, and measure the force at the same time. The distance between the lens and the plate was measured precisely by a device making use of light waves.

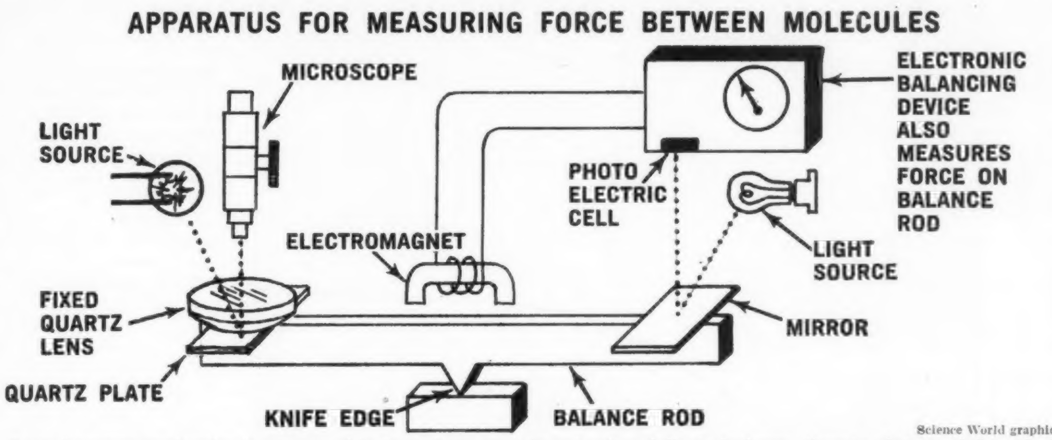
But problems still plagued the experimenters. Vibrations in the ground and buildings forced the scientists to mount the balance on a heavy pedestal—a cement pier sunk deep into the ground. Then it was found that air currents in the room upset the balance, so the equipment had to be enclosed in a vacuum chamber.

New Type of Force

The apparatus was finally ready about 1951. After analyzing the results of the first experiments, the scientists were dismayed to find that the measured forces were about 5,000 times greater than predicted by any theory. Then they discovered a flaw in the experiment. Electrostatic charges deposited on the glass plates were the cause of the excess forces. The charges were built up when the experimenters cleaned the plates with cotton dipped in ether to remove dust particles. The rubbing charged the plates with static electricity. The electrostatic charges were finally removed by placing radioactive material near the gap before the air was completely pumped out. The radioactivity ionized the air, and the ionized air conducted the charges away from the plates. The experiment could at last be performed.

The results confirmed a complicated mathematical theory and identified a fundamental force within matter. They provided evidence that the long-range forces between molecules were electromagnetic forces, created by the ceaseless vibration of the electrons in the molecules.

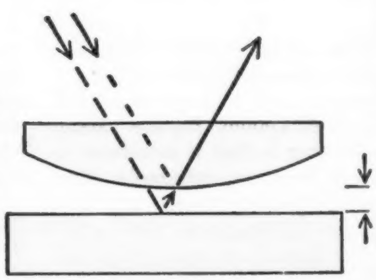
These are the long-range forces which draw molecules together into clumps large enough to be seen un-



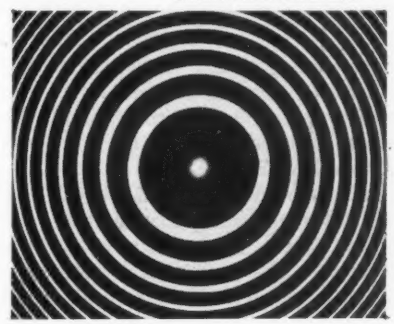
Science World graphic

Force between molecules is measured in ingenious experiment using delicate balance. Quartz plate on left end of balance arm is brought extremely close to fixed quartz lens, to distance where molecular force begins to act. Balance is automatically adjusted by electromagnet controlled by light beam from mirror. Amplifier measures force.

Science World graphic



National Bureau of Standards



Gap between quartz lens and plate is measured by means of Newton's rings. Light passes through lens, is reflected from plate. Part of light is reflected from lens surface, interferes with other light, creates rings.

der the microscope. (In contrast, short-range forces hold molecules together in crystals and compounds. These short-range forces are involved in chemistry and solid state physics.)

But there is an even more fundamental force. With identification of the particles in the nucleus of the atom, scientists have dared to ask the most basic question of all: What holds the nucleus together?

The answer to this question has dodged physicists for 25 years. All the forces with which we're familiar—electromagnetic, electrostatic, gravitational—indicate that the particles in the atom's nucleus should fly apart from each other. Instead, they cling so strongly that enormous atom smashers have to be built to pry them apart. The "glue" that holds the nucleus together is a type of force which is not in our experience.

Structure of the Atom

Scientists are familiar with the over-all structure of the atom. It is composed of a heavy, positively charged nucleus surrounded by a "planetary system" of light, negatively charged electrons. Scientists also are familiar with the forces involved in the movement of electrons—they are the electrical forces of attraction and repulsion. Most of what we know about atoms as a whole is based on studies of the motion of electrons around the nucleus.

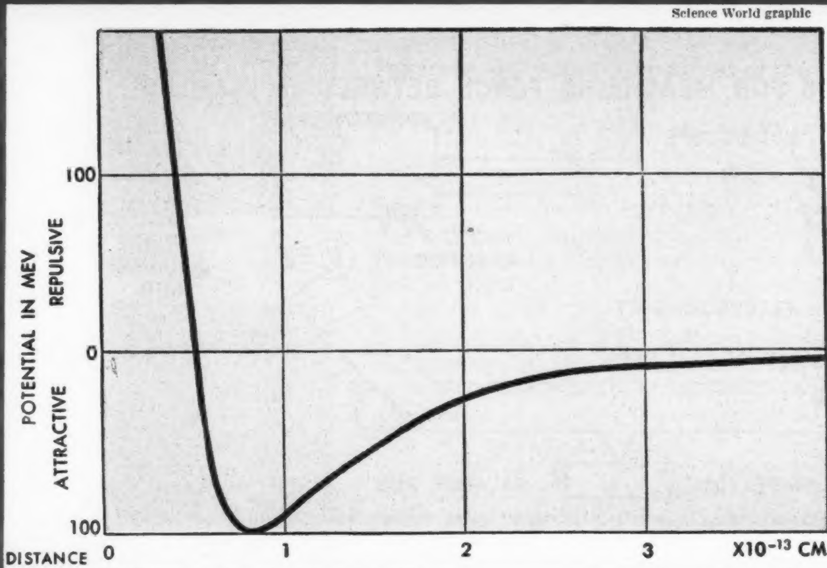
The nucleus itself is a different problem. Its building blocks are positive particles called protons, and neutral particles called neutrons. The nucleus contains 99.5 per cent or more of the mass of the atom. It is much more densely packed than the electrons in the atom's outer space.

If you were to imagine the atom as a whole to be as large as a house, the nucleus would be the size of a pinhead.

Another remarkable fact: The density of the nucleus is the same for all atoms. The volume of any atom's nucleus is very nearly proportional to its weight, just as a piece of iron ten times heavier than another piece of iron is also ten times larger.

This fact suggested to early experimenters that the forces binding the nucleus might be the same as those binding other bits of matter, such as the electric forces between atoms.

But scientists speculated that electric forces could not be responsible for holding a nucleus together. The only charges identified in the nucleus are the positive charges of the protons. Since like charges repel each other, the nucleus should fly



Force between nuclear particles changes with distance from attractive to repulsive. Strongest attraction occurs at just under 10^{-13} cm. Nucleons repel one another at distances less than half of 10^{-13} centimeter.

apart, according to this theory. But even if unlike charges existed in the nucleus, these electric forces would be much too weak to hold the nucleus together. We now know that at a distance of one fermi (10^{-13} cm.) the force binding the nucleus is 35 times stronger than the electrostatic force. (The *fermi*, named for the nuclear physicist Enrico Fermi, is a convenient unit of distance for studying the nucleus. In a heavy element, the diameter of the nucleus is about 15 fermis; the diameter of the entire hydrogen atom is about 100,000 fermis.) In addition to all these reasons, electrostatic forces do not explain how the uncharged neutron is held in the nucleus, since the neutron cannot exert any electric force.

Another familiar force, gravitation, also fails to provide the answer. It has been calculated that the gravitational force between particles in the nucleus is much too small to account for their sticking together. The actual measured forces holding the nucleus together are about 10^{37} times larger.

Both gravitation and electric forces operate according to the inverse-square law, where the force is inversely proportional to the square of the distance. But nuclear forces seem to operate according to laws of their own, entirely different from the inverse-square relationship. The nature of these forces has still to be discovered.

One well-known feature about nuclear force is that it manifests itself only over an extremely short range. The pioneer British physicist, Sir Ernest Rutherford, shot alpha particles through matter and found that he could not measure the nuclear force even when a particle approached a nucleus within a few nuclear diameters. Today we know that the nuclear force between two particles is negligible, if the distance between the particles is more than about four fermis.

Discovery of the Meson

Early researchers assumed that nuclear forces behaved like electromagnetic forces. The famous Japanese physicist, Hideki Yukawa, used this concept in 1935 in a dramatic example of the power of theoretical physics to deduce facts about the universe. Yukawa believed, according to his mathematical theories, that nuclear forces were transmitted from one particle to another by an undiscovered particle, one that had not yet been identified by experiment. He estimated that the mass of this theoretical particle should be about 200 times that of the electron. This particle would thus have a mass somewhere between that of an electron and a proton (whose mass is 1836 times as great as that of an electron). Therefore, he called his theoretical particle a meson, from the Greek prefix *meso*, meaning intermediate.

Yukawa also calculated that his mesons must be electrically charged. In this way he could explain how the nuclear particles overcome the nuclear forces and exchange mass and charge among each other. When a proton and a neutron interact, he postulated, the proton may emit a positive meson which is absorbed by the neutron. In this process the particle loses its positive charge and be-

Force of gravity between nuclear particles pulls them together, but it is too weak to account for measured nuclear force.

comes a neutron, while the neutron gains a unit of positive charge and turns into a proton. The same result is obtained if the neutron emits a negative meson, which is absorbed by the proton.

Yukawa suggested the existence of both negative and positive mesons, according to a general principle of physics: that for every positively charged particle there is a negatively charged counterpart.

When Yukawa suggested his theory in 1935, there was no evidence that a meson existed, and no known particle which resembled it. At that time Yukawa's meson was purely a product of theoretical speculation. However, physicists began actively to look for traces of Yukawa's meson, in cloud chambers and on photographic plates. Twelve years later, in 1947, three scientists—an Englishman, an Italian, and a Brazilian, working together—found Yukawa's meson. It was a particle which interacted strongly with other particles in the nucleus, and it had a mass of 276 electron masses — somewhat greater than Yukawa had predicted. However, this particle, called the *pi meson*, closely fitted the description Yukawa had deduced theoretically some twelve years earlier.

Meanwhile, the forces in the nucleus were being measured directly in the laboratory—by shooting one particle at another at high speed. For a brief moment they come close enough for the nuclear forces to come into play, and then separate. In this process the projectile particle swerves from its original path and the target particle is pulled out of position. By measuring these deflections, nuclear physicists can estimate the force that caused them.

The principle sounds easy, but the practice is very difficult. Such experiments are actually conducted using a dense beam of particles from a synchrotron or other accelerating machine. The beam of particles may consist of protons or neutrons. The beam is passed through a target material, and the experimenters then count the numbers of particles emerging at various angles. The target may be hydrogen, whose nucleus is a single proton, or deuterium, whose nucleus has a proton and a neutron, or in some cases a heavier element. Thus different combinations of atomic particles can be studied; such as proton-proton, neutron-neutron, and neutron-proton.

Brookhaven National Laboratory

Large cyclotron operating at energies of many million electron volts can produce mesons. The circular magnetic pole pieces are surrounded by thick concrete blocks.

This method is called "scattering." These experiments do not measure collisions between particles as much as they measure near misses, in which the particles momentarily deflect each other when they are within range of the nuclear force. We can visualize the process if we think of a rocket vehicle shot from Earth swinging part way around the moon, and then heading into outer space. However, the rocket would have to be as heavy as the moon and pull the moon out of its course as it went by.

Experiments Continue

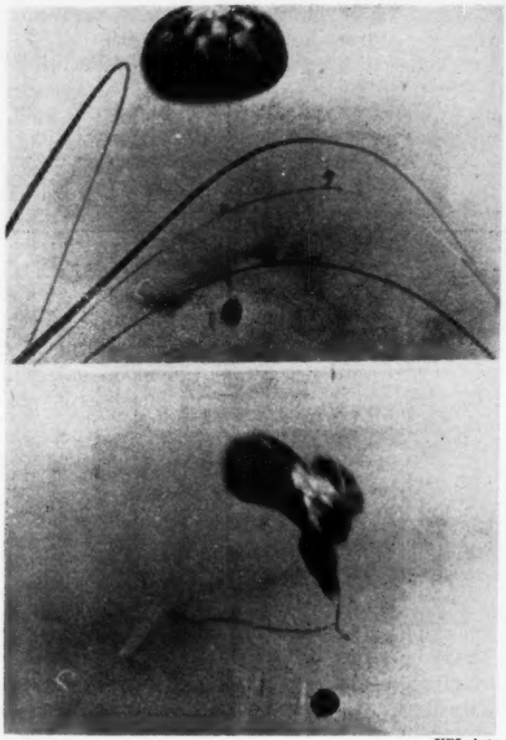
If the energy of the beam of particles is sufficiently large, the particles do not simply deflect around each other. Instead, new particles are created in a nuclear "collision," particles such as Yukawa's pi mesons, or pions.

At lower energies, the scattering experiments allow scientists to study only the force between two particular particles, such as the proton-proton interaction. Since protons are electrically charged, they are easier to handle than neutrons, and therefore have been studied more extensively. Since the protons are charged, they can be focused, accelerated and aimed by magnetic and electric fields.

The forces between protons have been fairly well established, and the forces between neutrons seem to be identical to those between protons. However, scientists have only a limited theoretical understanding of the nuclear forces. If Yukawa's famous conjecture was correct then the pion is the "carrier" responsible for the force between two particles.

Mathematical equations based on the pion can be developed, but there is no known way to solve them. Therefore, it is impossible to know whether the equations are correct. But nuclear physicists are confident that one day they will be able to formulate equations for the nuclear forces, solve them, and then check their results in the laboratory.

Meanwhile, physicists have no choice but to continue experiments which may yield new data, and lead to new and more fruitful theories on the "glue" of matter.

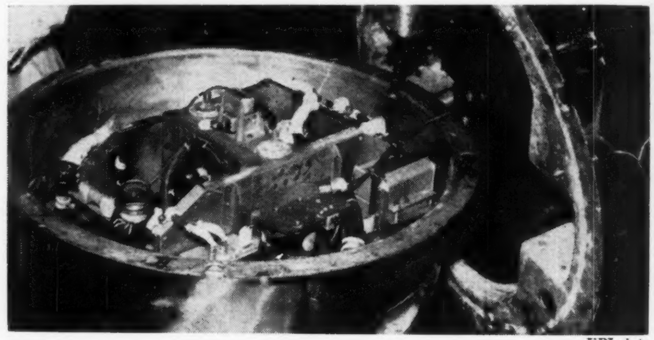


UPI photo

1. Nylon cables trail behind U. S. Flying Boxcar as it misses *(top)*, then snags *(bottom)* space capsule.

UPI photo

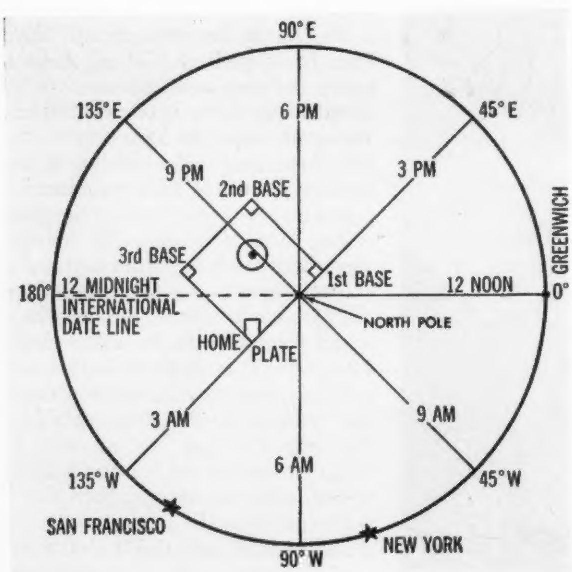
On seventeenth pass, capsule was ejected, parachuted toward Pacific Ocean. After space capsule was snagged, winch slowly reeled it in.



UPI photo

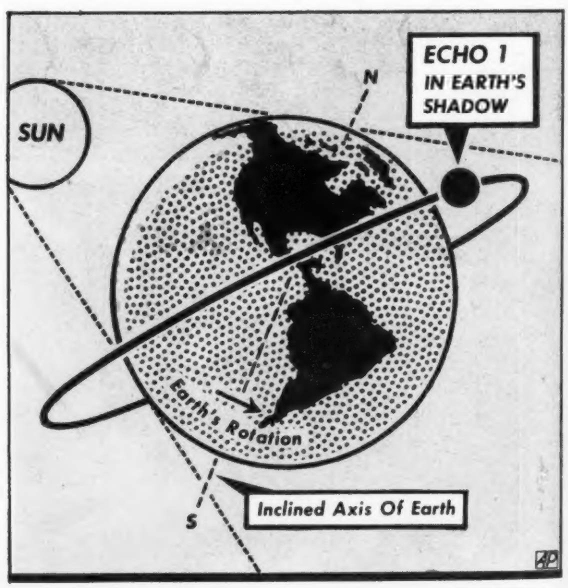
Space capsule was orbited inside Discoverer XIV satellite. Capsule weighed 85 pounds, was crammed with delicate scientific instruments.

Science in the news



Science World graphic

2. During baseball game at geographic North Pole, ball is thrown by pitcher at 9 p.m. Ball reaches home plate at 3 a.m. the day before—30 hours *before* ball was pitched.



Wide World photo

3. Echo I satelloon orbits around Earth once every 118 minutes. As days grow shorter in Northern Hemisphere, Echo will pass into longer and longer periods of darkness.

UPI photo

4. **U. S. rocket plane, X-15, shown dropping away from "mother" plane, set new speed record of 2,196 mph. A week later, X-15 set altitude record of 136,500 feet (26 miles). At that altitude, X-15 was above 99 per cent of Earth's atmosphere.**

Wide World photo

6. **Air Force Captain Joseph Kittinger stepped out of balloon's gondola at altitude of 102,800 feet (19.5 miles) . . .**

UPI photo

. . . Kittinger plummeted earthward, twisting and turning. Velocity hit 450 mph. After 17 miles his parachute opened . . .

UPI photo

. . . About 13 minutes after jumping, Captain Kittinger landed in New Mexico desert, elated over his record jump.

What's Behind the Photos

1. SKY SNATCH. The U. S. was the first nation to recover a payload from orbit around the Earth. Last month two payloads were recovered. One was snagged over Pacific by a Flying Boxcar.

2. POLAR BASEBALL. The nuclear submarine *Seadragon* made an under-the-ice crossing of the geographic North Pole. When the *Seadragon* surfaced at the pole, her crew took time out for a quick game of baseball. Because all time zones meet at the pole, it was a crazy mixed-up ball game. When a hitter belted a home run, he ran from today into tomorrow and back into today.

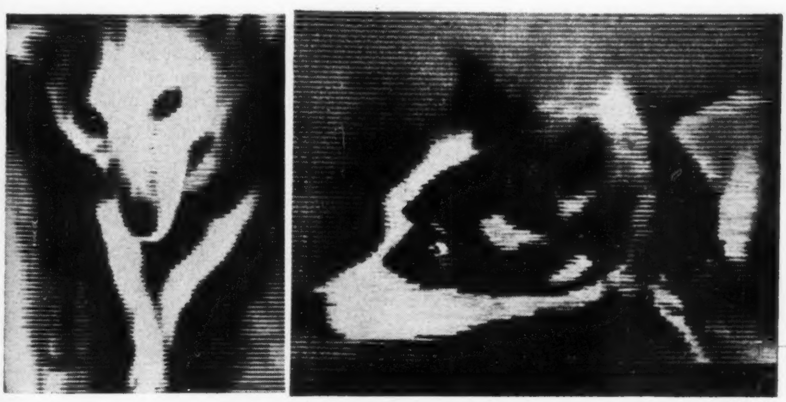
3. ECHO SATELLOON. U. S. rocketeers launched a satelloon—an inflatable satellite 100 feet in diameter. It was made of aluminized film about half the thickness of cellophane.

Echo's shiny surface was used as a reflector in a series of experiments. In the first experiment, a pre-recorded message by President Eisenhower was bounced off the satelloon. The message was sent from the Jet Propulsion Laboratory in Goldstone, Calif., and received by a Bell Telephone Laboratories installation in Holmdel, N. J.—as clear as "a local telephone call."

Each installation was equipped with a "dish" antenna to focus messages on the satelloon—and a very sensitive radio receiver (called an "ear"). As Echo streaked across the U. S. at 16,000 mph, messages bounced back and forth.

4. HIGHEST AND FASTEST. The X-15 rocket plane shattered speed and altitude records last month. It flew faster and higher than any other plane in the world. This month an X-15 is being fitted with a power plant four times more powerful.

5. SPACE DOGS. Two Soviet space dogs looped the Earth 17 times and then were brought down alive. The Soviet space capsule weighed five tons—five times heavier than the U. S. Project Mercury space capsule. Soviet scientists reported that the dogs were "in perfect condition." The capsule was probably parachuted to the ground.



Sovfoto

5. **Belka (Little Squirrel) and Strelka (Little Arrow) were orbited by Soviet rocketeers and brought down alive to Earth. Photos were televised to Earth from outer space. Soviet capsule also contained rats, mice, seeds, plants, fungi, and fruit flies.**

today's scientists

DR. ALBERT SABIN—VIRUS HUNTER

A DRAMATIC announcement was made last month by the Surgeon General of the United States Public Health Service—one that made headlines across the nation. The United States Government was approving the use of a live poliomyelitis virus vaccine.

To one man the announcement held no surprise—Dr. Albert Bruce Sabin, who had developed the vaccine. For five years the Sabin vaccine has been widely used throughout the Soviet Union, Czechoslovakia, Mexico, and other areas. It is believed to be more effective than the Salk vaccine. It is also easier to administer, and less expensive to manufacture. To millions of people in underdeveloped nations, the Sabin vaccine will mean protection against polio at one tenth the cost of the Salk vaccine.

This live virus vaccine is the product of 25 years of intensive, creative research by Dr. Sabin. Yet these years might not have been spent in medical research had not Dr. Sabin made an early decision to forsake dentistry for medicine.

Dr. Albert Sabin was born in 1906 in Bialystok, then part of Russia but now in Poland. At 15 he emigrated with his family to the United States. To help

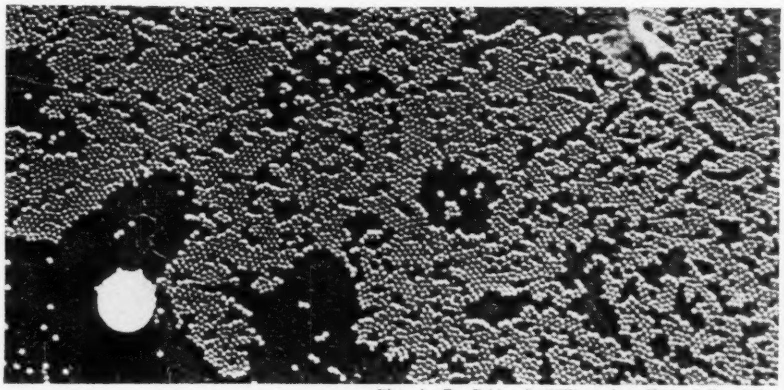
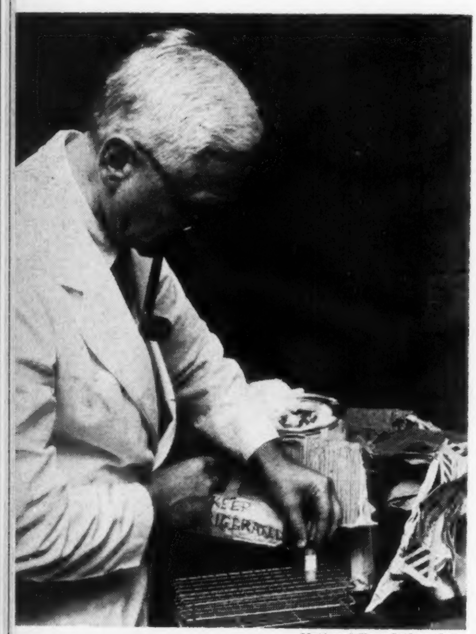


Photo by Dr. Robley C. Williams from National Foundation

Colony of polio viruses is shown enlarged 60,000 times by electron microscope. White sphere at lower left is chemical droplet of known size used for size comparison.



National Foundation photo

With one laboratory victory behind him, Dr. Sabin is attacking problem of cancer.

the struggling family, an uncle offered to pay for Albert's education—provided he studied dentistry. Albert accepted the offer and for two years diligently applied himself to dentistry. The turning point of his life came when he read a book. The book was Paul de Kruif's *Microbe Hunters*.

"The biographies of scientists in that book gave a picture of what science really meant, and influenced my decision to turn to medical research," he told us.

Started as Lab Volunteer

His mind made up, young Sabin left dental school to prepare for a career in research. He worked his way through New York University's undergraduate school and school of medicine. There, one of the faculty members was a famous microbiologist, Dr. William H. Park. Young Sabin approached Dr. Park and asked for laboratory space where he might try his hand at research. Dr. Park granted the unusual request.

"During the next several years Dr. Park suggested various projects to me," Dr. Sabin related. "One of these was my first introduction to polio research. I spent six months checking a skin test then used to diagnose polio. I found that the test was unreliable."

Four years later, in 1935, he received an appointment to the Rockefeller Institute in New York City. There he helped to establish that the polio virus could grow outside the body, on nervous tissue in test tubes.

In 1939 he was invited to Cincinnati University's College of Medicine, where he has remained as a teacher and researcher. During his first few years there, he found that polio viruses thrive in the intestine. Work on a vaccine, however, was interrupted by World War II and service in the Army Medical Corps. After the war, Dr. Sabin returned to Cincinnati and his laboratory.

The breakthrough year in polio research came in 1949. That year a team of Harvard scientists, headed by Nobel-prize winner Dr. John F. Enders, discovered how to grow the polio virus on types of tissue other than nervous tissue. A path was cleared. The virus now could be grown more easily. Researchers concentrated on finding a type of the virus suitable for a vaccine.

Vaccination is a process that enables the body to resist disease. Scientists have found that the introduction of vaccines (damaged or even killed disease bacteria or viruses) may provide immunity against the corresponding *living* organisms. The immunity process is still a puzzle to scientists, but they know that immunity results from the presence of defending substances (known as *antibodies*) formed when the body tries to protect itself against invading microorganisms (*antigens*).

Mysterious Invader

To understand what is known of this process, it is helpful to think of antibodies disarming antigens, and destroying their ability to multiply. When antigens multiply at a rate greater than the body's capacity to produce antibodies, disease results.

(Continued on page 34)

PROJECT: Life Cycle of Coturnix, A New Laboratory Animal

Student: **SARAH JOHNSON,** Grade 9, Future Scientists of America Award Winner

School: T. R. Robinson High School, Tampa, Florida   Teacher: **NELSON HOWE**

[Sarah Johnson spent her last Christmas vacation at the Germfree Life Research Center at Tampa, Florida—working out the life cycle of the Japanese quail, *C. coturnix japonicqa* Jemmick and Schlegel. Her work was directed by Dr. James A. Reyniers, a pioneer in germfree environment research. The photographs that Sarah made as part of her project are the first photographs of the development of coturnix to be published anywhere.]

SARAH'S PROJECT

The coturnix quail is useful in research. Its small size and short life cycle make it ideally suited for maintenance in a sealed environment necessary to maintain germfree conditions for experimentation.

Coturnix is prolific, hardy, and easy to raise. It hatches in 16 to 18 days and matures at 6 weeks of age. The coturnix is not susceptible to any of the common diseases of the native bobwhite quail.

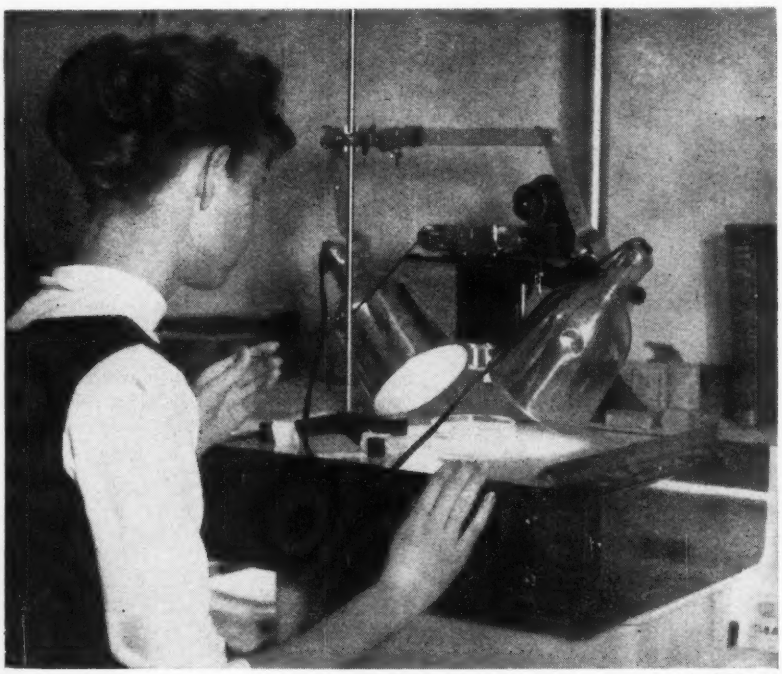
The coturnix develops very rapidly. The birds more than triple their size and weight during the first week after hatching. The first flight feathers are evident at three days of age, and strong flight is possible at two weeks. The birds are sexually mature at six weeks of age. A few may lay eggs as early as 38 days. Fertility is low at first, but by 50 days of age, the fertility may be as high as 90 per cent.

The eggs may be snow-white, flesh colored, dark- or light-brown. They may be speckled with blue, blue-violet, mottled brown, or any combination of these. The size of the eggs varies greatly. Some may be as small as 20 mm. Others may run to 35 mm. But compared to the size of the adult—the eggs are quite large.

In preparing the eggs for incubation, I first scrubbed them under running water. If the scrubbing takes place soon after the egg is laid, it is possible to scrub off the speckles. This makes a pure white egg that can be marked with India ink for indentification. The identifying marks were made at the small end of the egg. If they were done at the large end, the markings would have been lost when the chick pipped (broke the shell to get out).

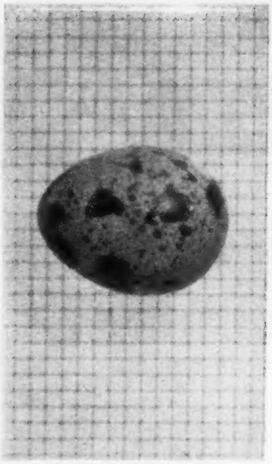
The average incubation period for the egg in an incubator at 100° F. is sixteen days, eight hours. Incubator temperatures of 103° F. or above are harmful, and hatchability at these temperatures is low. During incubation humidity should be kept at 60 to 70 per cent. Throughout incubation, the eggs should be turned at eight-hour intervals. Humidity should be raised to about 95 per cent on the fifteenth day for highest hatchability. The hatch, based on the number of fertile eggs, runs about 60 to 70 per cent under artificial incubation conditions.

Each tiny quail, as it emerges from the egg, is a complete individual. It has two legs, two eyes, a heart, and a nervous system. But not long ago—before hatching—none of these things existed. There were no heart, liver, legs, nor eyes. Yet all the raw materials necessary were present.

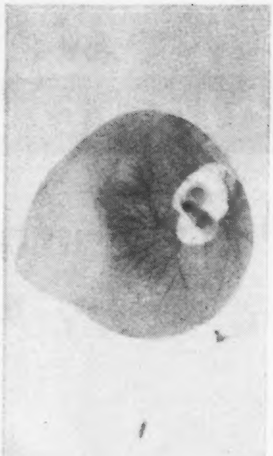


Sarah Johnson

Sarah placed each embryo in a solution of glycerin and water in a petri dish. Then the specimen and identifying card were placed on lighted screen to be photographed.



Blue and brown speckled egg is tiny, about 20-to-30 mm.



In 54-hour embryo, heart functions. Eye is visible.

Eyes are the most prominent feature of 6-day embryo.

Eight-day embryo shows both rudimentary wings and legs.

On day-10, down begins to show. Wings, feet are larger.

Between days 10 and 12, embryo's size increases fast.

By day-15, chick is covered with down, feet are formed.

Even after 16 days, little coturnix is not impressive.

Just hours away from hatching 17-day chick is well formed.

Hello world! Chick and modish bustle are 2 inches long.

Photos by Sarah Johnson

Size of adult can be determined by grid of 10 squares to inch. These are first published photos showing coturnix.

The beginning is an egg from the mother. All life, except the most primitive, begins with the egg.

The sperm cell carries the hereditary characteristics from the father. The hereditary characteristics of the mother are in the egg. They join to form a single fertilized cell. The single cell pinches in two. Half of everything in the cell goes to one part, half to the other. Now there are two cells. Each has its own nucleus. Both are identical, both are developing, and both are alive. A short period of preparation follows and then, again, activity within the cells. Each cell pinches in two, and divides. Two cells become four. Four cells become eight. At this stage, their total size is no greater than that of the original fertilized cell.

Dividing and dividing, they form a cluster of cells. Now the cells number hundreds and division is no longer so regular. Geometrical progression ceases. Thousands—millions more will grow from them. This is the way life develops in all the vertebrate animals: fish, amphibians, reptiles, man, and birds. This, of course, includes the Japanese quail.

PROJECT: Utilization of Cornstalk Waste

Student: **DAVID SCHUBERT,** Grade 11, Future Scientists of America Award Winner

School: Thomas Carr Howe High School, Indianapolis, Ind. Teacher: **WILLIAM M. SMITH**

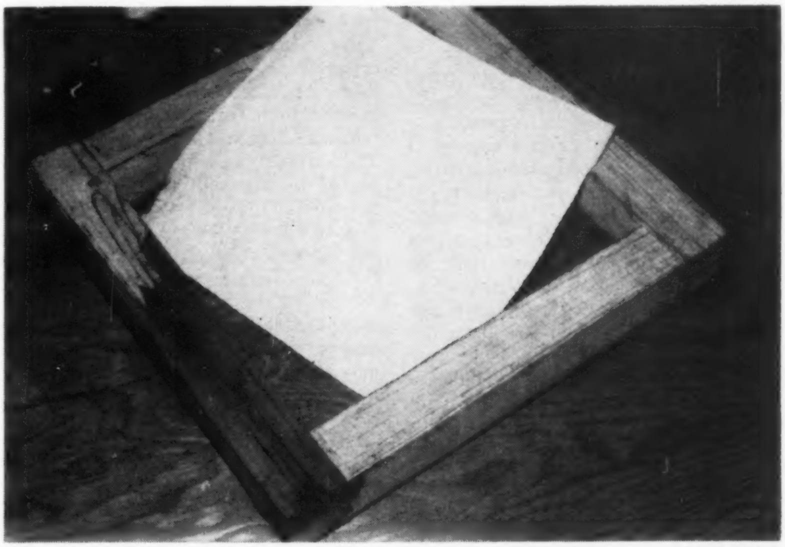
[Sometimes we call our age the Atomic Age—sometimes the Space Age. Both imply a civilization greatly influenced by science and technology.

We might also call the twentieth century the Age of Paper and Fiber. It is hard to imagine all of the difficulties that would occur if paper were to disappear overnight. Without paper, our technical civilization would collapse. In 1958, the U. S. alone consumed almost 31 million tons of paper.

The basic and essential ingredient of wood, paper, paper products, and cotton cloth is *cellulose*—$(C_6H_{10}O_5)n$. The *letter* "n" means that the cellulose molecule is composed of a large number—n—of units $C_6H_{10}O_5$. All cellulose comes from plants—mostly from wood. Each year the demand for cellulose increases, and our forest reserves decrease.

So, if we are going to keep on expanding our use of paper, rayon, film, cellophane and building board—and there is no reason to believe that we won't—new sources of supply are needed. The development of new supplies calls for new technology to retrieve the cellulose in useful form.

David Schubert has made a step in this direction.]



David Schubert

Frame, shown above with sample of cornstalk paper, was used in paper making process. Pulp was poured into frame over nylon cloth bottom. Paper was heat-finished.

DAVID'S PROJECT

Cornstalk, like wood, contains *lignin,* a compound which cements the cellulose fibers together. In order to utilize the corn stalk's cellulose, it is first necessary to remove this substance.

The basic process of dissolving and removing lignin from the stalk is best accomplished by cooking shredded stalks with a caustic liquor in a pressure vessel for two hours at a temperature of 140°C. Great caution must be used in this step because the pressure builds up to 15 pounds/in^2. The caustic liquor consists of 20 per cent NaOH and 5 per cent Na_2SO_4 by weight in water. It is used with a ratio of 5 parts stalks to 3 parts cooking liquor by volume. It is necessary to vent the cooker for the first few minutes of the cooking cycle to exhaust the air. After the completion of the cooking, the pressure vessel is thoroughly cooled until the gauge drops to zero. Otherwise, upon opening, the alkali might splash in the operator's face. The stalks are then defibered in a beater and thoroughly washed to remove all of the liquor.

The liquor-free raw pulp is bleached in 30 per cent solution of sodium hypochlorite for 12 hours. When bleaching is completed, the pulp acquires the white, fibrous texture of nearly pure cellulose.

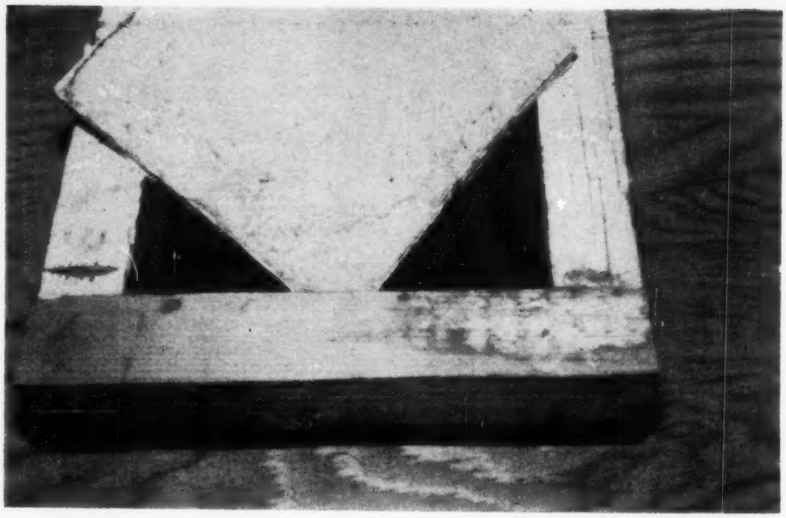
The process we used in the laboratory for making paper is simple, but productive. The mold used to form the individual sheets of paper consists of a 12" x 14" rectangular frame made of 2" wood. A double thickness of nylon is

tightly stretched across the bottom of the frame, and held fast by a thin molding. This mold is placed in a basin containing 2 inches of water. A suspension of pulp in water is poured into the submerged mold and the water is gradually drained from the basin.

After the sheet becomes dry enough to move, it is placed on a photographer's ferrotype board or pressed with a hot iron to insure a smooth surface. This paper has an excellent texture for water color paints.

We found that an excellent insulating board can be made from cornstalks. In the preparation of insulating board, it is not necessary to refine the stalk to the degree required for paper. About 1½ hours cooking time proved sufficient.

The preparation of insulating board is very similar to the method for making paper. Pulp is placed in the mold to the desired thickness. After settling, the mold was placed in a fitted press at 5 lbs. pressure/in^2. After the water is drained from the press, the whole unit is dried in a ventilated oven at 120°C. for 10 hours.



David Schubert

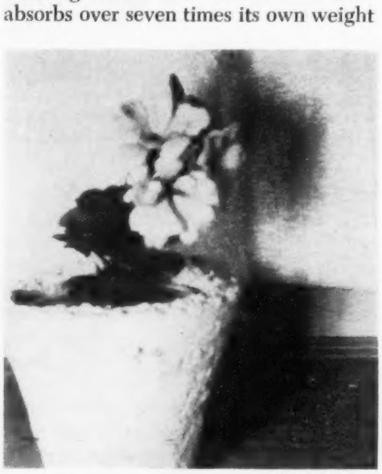
Among the many products produced from cornstalks was a heavy, durable building board called mazolith. Mazolith shrinks when drying but can be cut to desired shape.

Boards from Cornstalk

By regulating the amount of pulp, hydration, pressure, and drying rate of the board, it is possible to produce a board of almost any desired quality.

The hardest type of board-like material that we were able to make is known as mazolith. There is a large amount of shrinkage during the drying of mazolith. But the dried board can easily be cut to any desired size and shape.

When semi-hydrated pulp is placed in a beater for 15 minutes, it takes the form of tiny, fibrous beads. This material has many uses: for packing delicate glassware or any other breakable item, insulation, or as a filler and binder for building blocks and bricks. The fiber absorbs over seven times its own weight in water in one minute. This property may make the fiber useful as a dynamite absorbent or in surgical "sponges."



David Schubert

An inexpensive flower pot molded from cornstalk pulp supplies humus for plants.

Another practical application for the cornstalk fiber is in the construction of flower pots. A flower pot cheaply molded from cornstalk pulp serves as both container and fertilizer for its plant. The whole unit—pot and plant—is placed in the soil. After the plant is thoroughly soaked, the pot begins to decompose with the aid of the roots and soil bacteria. The plant quickly utilizes the small amount of nutrient material present in the pot, but the remaining roughage serves as needed humus. If desired, a small amount of fertilizer may be added to the pulp before molding the pot.

Cornstalk Rayon

In order to produce rayon from the relatively impure cornstalk cellulose, it was necessary to adapt several changes in the commercial viscose process.

The first step was to place about 50 grams of bleached pulp in one liter of 35 per cent NaOH. Here, again, the use of a strong lye solution calls for extreme caution. After the pulp has remained in solution for 15 days, it is removed and thoroughly dried between sheets of absorbent paper to remove as much sodium hydroxide as possible. The resulting alkali cellulose was immediately submerged in carbon disulfide for 14 hours to form a deep red compound, cellulose xanthate. The excess carbon disulfide is removed from it by evaporation. (This process should be carried out over a water bath under a chemical hood.) To form viscose, the cellulose xanthate is finely divided and placed in a 5 per cent solution of sodium hydroxide for 8 hours, stirring frequently.

Rayon is made by forcing the viscose through a glass capillary into dilute sulfuric acid (2-7) by using a glass syringe. It is necessary to apply pressure on the viscose thread before it touches the acid. Otherwise, it hardens at once and plugs the capillary's orifice. With forceps, the thread of rayon is pulled through the acid, hung to dry.

Of the numerous complex chemicals now on the market, perhaps none may be used in as many capacities as furfural. Furfural is an excellent solvent for most cellulose compounds. It can also be used in dyes, as a weed killer, and for treating seeds to eliminate parasitic fungi. Furfural is also widely used as a selective solvent in refining processes. A large variety of products are made from furfural-phenol resins.

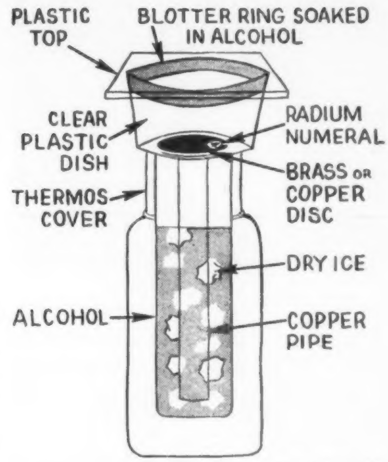
Furfural is prepared in the laboratory by treating raw cornstalks with dilute acid and heating. In this process, certain sugary materials, *pentosans*, are hydrolyzed to form sugars. These, in turn, are converted to furfural.

About 10 grams of finely divided stalk are placed in a glass retort with 20 ml of 15 per cent H_2SO_4. After 5 minutes, the acid is slowly boiled (use care to prevent splashing) until the solution ceases to yield the oily, light brown liquid. Nearly 40 ml. of furfural can be condensed from 10 grams of dry cornstalk.

Man may soon find it necessary to utilize fibers other than those from trees to fulfill his increasing demands for cellulose. Cornstalks may be one answer to our problem. Cornstalks are economical, widely distributed, and available in large quantities.

By ALEXANDER JOSEPH

PROJECT POINTERS



Science World graphic

Cloud chamber is built from thermos bottle, copper tube, brass disk, plastic dish. To study atomic particles, thermos is filled with dry ice and rubbing alcohol.

The Glue of Matter

The attractive force between molecules in a liquid causes such phenomena as surface tension. The force of surface tension in water can be measured by using a glass disk about two inches in diameter. At four points around the circumference of the disk (90 degrees apart), cement one end of two-foot lengths of thread. Join the other ends together and hang the disk from a low range spring balance (0-30g). If you do not have such a spring balance, use a light-weight helical spring. It can be calibrated by attaching gram weights.

Next, place the glass disk on a water surface, making sure the disk is parallel to the water. Measure the force of surface tension with the spring balance by pulling upward. The amount of surface tension is surprising. Calculate the area of the disk in square centimeters and divide this into the force of surface tension as measured. The result is the surface tension per square centimeter. You then can try the effect of dust or oil on the surface and the effect of wetting agents as found in detergents. Test with different concentrations.

Simple Cloud Chamber

To study atomic particles such as alpha and beta, you can build a simple diffusion cloud chamber by using a 12-ounce or one-pint wide-mouth thermos bottle. The thermos is first filled with small pieces of dry ice and then with rubbing alcohol. The small vacuum bottle will maintain the necessary low temperature. You will then need about 5 inches of copper pipe or tubing with a diameter that may vary from ½" to1". Solder one end to the center of a 2-inch disk of brass or copper. The other side of the disk should be painted with black oil paint or black enamel. Do not use laquer. Next, take the top cover of the thermos bottle and make a hole in its top big enough to allow you to pass the copper tube through it with a loose fit. Then get a small transparent plastic food dish about the size of a teacup. Make a hole in the center of the bottom to allow the pipe or tube to pass through. Now assemble the parts. Pass the open end of the tube through the plastic food dish so that the disk remains inside the dish. Then pass the tube through the hole made in the thermos bottle cover. Place the end of the pipe into the dry ice and alcohol mixture in the thermos bottle and screw the cover on.

An old radium watch dial obtained from a jeweler can serve as a source of radioactivity. First place the dial in a dark drawer for a few days. If it glows in the dark at the end of that time it is a radium dial. Some watch dials use phosphors which store light energy during the day and glow for a few hours in the dark. These dials are not radioactive. Snip away one number on the dial and place it with a tweezer on the black painted metal disk, with the number facing up. Then cut out a strip of blotting paper ½" wide and long enough to fit completely around the inside circumference of the plastic dish just below the top. Soak this blotting strip in rubbing alcohol and place it in the dish. Cover the clear plastic food dish with a 4" x 4" square of lucite or plexiglass. Shine a strong flashlight across the bottom of the dish so that the rays move over the top of the metal disk. Next rub the top of the lucite square with a piece of silk to give it an electrostatic charge.

Photos of Alpha and Beta Tracks

When the chamber is cold enough (this may require a ten-minute wait) you will begin to see alpha particle tracks streaming away from the radium number. If you use the chamber without the radium dial, you can occasionally observe cosmic rays. To see beta particle tracks hold a radium watch dial against the outside of the dish, after removing the crystal face from the watch. Beta tracks are wispy and curly. Alpha tracks are straight and heavy. Cosmic rays will move completely across the chamber, entering and leaving through the walls. You can take photographs of the tracks with a triple-x film if the light source is a 300-watt projector in place of the flashlight. 1/25th of a second exposure is fast enough with an f2 lens.

For taking movies, simply use fast black-and-white film of the same speed as plus-x with an f1.9 or 2 lens. As a project, you can take the movies and examine each frame to see when alpha tracks started. Since each frame is 1/16 second apart, collect data on the number of new tracks that appear each 1/16 sec. You will find that the results will differ. But if you look at 320 frames separately and then at another 320 frames the average will be the same. However, the number counted per 1/16 second will vary. This fact indicates that radioactive disintegration is a quantum phenomenon. The average number of particles released over a long period of time is almost constant (for radium), but the individual particles are released in bursts which are not evenly spaced.

Additional Starters

Have your science teacher write to a large nuclear research center, requesting a loan of exposed nuclear plates that have recorded cosmic rays. These can then be examined under the microscope to study the nuclear events.

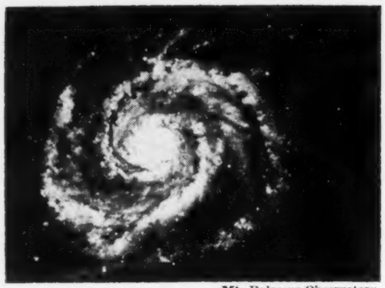
Light and Life

1. Grow plants behind movable shutters that produce different long periods of dark and light. Compare growth.

2. From a large plant nursery supply house or chemical supply house buy a one dollar bottle of auxin. Apply it to leaves and stems with a paint brush. Observe the effects.

Gravity

Make an accurate seconds pendulum that balances on a knife edge made from an injector razor blade. Drive the pendulum electromagnetically, then use it to control a clock movement.



Mt. Palomar Observatory

The Processes of Science

Hello, Out There!

By THEODORE BENJAMIN

WHEN we think of a scientist, we usually envision a man toiling in the laboratory, surrounded by complex apparatus. We rarely think of a group of people, sitting around a table, discussing the problems of the moment, or even of a solitary man, seated comfortably in his armchair, and employing the most versatile tool of all—the human brain.

How well can you think a problem through to a valid conclusion when given the basic facts in a situation? Using the following discussion as your springboard, try to answer the questions at the end of the article. You can have even more fun if you get a group of your science-minded friends together and use the questions to spark a roundtable discussion.

•

The Special Theory of Relativity makes a remarkable prediction. It predicts that a space traveler moving with a speed approaching that of light (186,000 miles per second) will experience a time change. His clock, compared to one on the Earth, will run slower. Not only will his clock run slower, but all the other time processes, including those of aging, will also slow down. He, of course, will not feel this time dilation.

Message Cheaper Than Man

Suppose a space traveler is moving at nine tenths the speed of light (written as 0.9C). If he takes a trip of one year's duration (by Earth standards) at that speed, the theory predicts his clock will indicate that the trip took ½ year and he will have aged only ½ year.

Unfortunately there are several practical problems that may be very difficult to solve. Let us assume that the space ship is fueled by the most powerful fuel known to man—the fusion of hydrogen to helium. Let us further assume that the hydrogen is converted to helium with 100 per cent efficiency—that is, all the energy produced goes to moving the space ship forward. To get the ship moving with 0.9C, the ratio of the take-off weight to the final weight of the payload would be 10^{21} to 1. In other words, to accelerate a 1-ton mass to nine-tenths the velocity of light would require 1 followed by 21 zeros tons of hydrogen. There just isn't that much hydrogen available on Earth.

However, at the present state of the art of communication, one kilowatt of electrical energy, 5¢ worth at current rates, can send a 60-word telegram a distance of 1 light year. If we are to send anything to the distant stars, it seems quite evident that we shall not send matter (which includes men), but rather we shall send radio waves.

It is possible that somewhere within the reach of our radio transmitters there is a race of intelligent beings sufficiently advanced in the art of electronics to receive our signals and respond to them. If such a distant race of intelligent beings exists, they may already know what we know and, at this very moment, may be attempting to communicate with us.

What leads us, in the first place, to believe that life exists elsewhere in the universe? The answer lies in the sheer weight of statistical probability. Our galaxy contains almost 100 billion stars. Some are younger and some are older than our sun. No matter what special conditions may have been necessary to produce our planet and its subsequent life, somewhere in our galaxy or in the hundreds of millions of galaxies like our own, the same conditions are almost certain to have prevailed.

A detailed look at stars within 100 light years of the Earth shows many exciting possibilities.

The type of star in which we would be most interested is one similar to our sun. Furthermore, we would also look for the ones possessing a rather slow rotational rate (small angular momentum). We look for this low angular momentum because we are fairly certain that in the process of throwing out its planets, a star will lose some of its rotational energy.

Within 15 light years of the Earth there are two stars which more or less meet our criteria. They are stars known as Tau Ceti and Epsilon Eridani. It is estimated that within 100 light years there are more than 20 similarly good prospects.

If we are to direct radio signals at these stars or listen in for signals from intelligent life on their planets, an important question must first be settled. On what frequency should we transmit or listen? If we had to listen for a weak signal against the background of static all the way across the dial from 50 megacycles to 50,000 megacycles, a lifetime would not be sufficient to explore the radio waves from even one star.

Noise from Milky Way

Is there one logical frequency that we might try? In 1931 the late Karl Jansky, a radio engineer from Bell Telephone, sought to track down the source of the background noise that can be heard in any radio receiver when the volume is turned full up and no station is tuned in. He came upon the startling discovery that some of the noise came from outer space in the direction of the Milky Way.

The origin of these radio waves is in the excited atoms that make up the stars. By far the most prominent source of the waves is excited hydrogen atoms which "broadcast" on a frequency of 1420 megacycles. By radio astronomy,

(Continued on page 34)

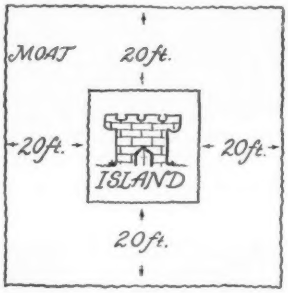
NASA photo

BRAIN TEASERS

Do you have a favorite brain teaser? Send it to *Science World*, 33 West 42nd Street, New York 36, N. Y. We will pay five dollars for each one published. Include the name of your school, home address, and age.

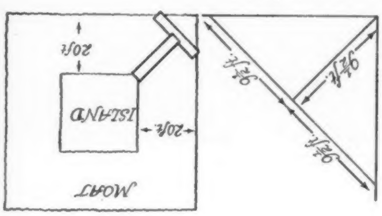
Storming the Castle

Once upon a time there was a castle on a perfectly square island. The island was surrounded by a moat 20 feet wide, as in the drawing below:



A spy sent to enter the castle and open the gates reached the moat, where he found two planks, each 19 feet long. He found a way of using the planks to cross the moat without getting wet. How did he do it?

Paul A. Crim
Stratford, Iowa



Answer: The spy took one of the planks and placed it across one corner of the moat. If the ends of this 19-foot plank just touch the edges of the moat, the center of the plank will be 9½ feet from the corner of the moat. This can be seen by dividing the area into two right triangles (*see diagram*). From this, it can be seen that the second plank is long enough to reach from the center of the first plank to the corner of the island. The distance between the corner of the island and the corner of the moat is the hypoteneuse of a right triangle whose sides are 20 feet each (*see diagram*). By the Pythagorean theorem, the length of the hypoteneuse is the square root of 20^2 plus 20^2 (square root of 800), which equals approximately 28 feet. This means that the center of the first plank is about 18½ feet from the corner of the island. Therefore, the second 19 foot plank can just span this distance, with a few inches left over for support.

Fair Split

Two children often divide a piece of property, say a pie, by having one of them divide the pie into what he considers to be two equal shares, so that he will be content with either share. The other child is then allowed to choose the portion that he prefers. If there were three children, instead of two, all three desiring a fair share of the pie, could the problem be solved? Each child must be satisfied that he is getting at least his fair share of the total (at least one-third).

Donald Dilbert
Los Angeles, California

Answer: Suppose we call the three children, Albert, Betty, and Charles. One of them, say Albert, divides the pie into what he considers three equal shares, A, B, and C. Since he divided them, Albert will be satisfied with any share. If Betty thinks that A is the biggest and Charles thinks that B is the biggest, then there is no problem. Betty gets A, Charles gets B, and Albert gets the remaining piece, C. Suppose that both Betty and Charles agree that A is the biggest and B is the second biggest piece. This is simply solved by letting Betty and Charles divide both A and B between them. Again, Albert is left with C. The only difficulty occurs when Betty and Charles agree that A is the biggest, but Betty thinks that B is the second biggest and Charles thinks that C is the second biggest. See if you can solve this situation yourself.

Dollar Digits

What are the chances that a dollar bill found in the street will have 6, 8, or 0 in its serial number?

Daniel P. Smith
Scarsdale, New York

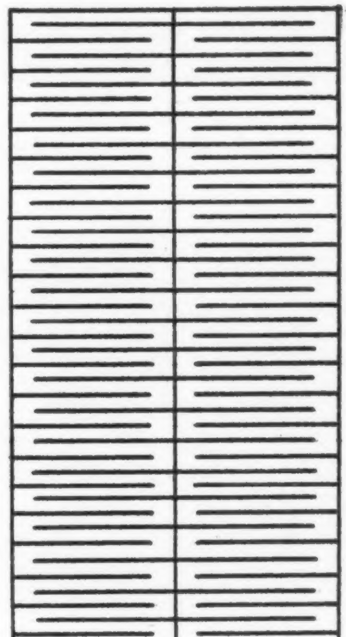
Answer: Each digit in the serial number can be any number from zero to nine. Therefore, each digit has seven chances in ten of *not* being 6, 8, or 0. Since there are eight digits in a serial number, the total chance of not finding a 6, 8, or 0 is $7/10 \times 7/10 \times 7/10 \times 7/10 \times 7/10 \times 7/10 \times 7/10 \times 7/10$, or $5764801/100{,}000{,}000 = 1/17$. This means that one out of 17 bills will not have a 6, 8, or 0, and that 16 out of 17 bills will have at least one of the digits 6, 8, or 0. Any three digits can be used.

Paper Problem

Can you cut a 3 x 4 inch piece of paper so that there is a hole in it large enough to pass your body through?

John Knudtson
Smyrna, Tenn.

Answer: If the paper is cut along the lines shown below, it will make a loop large enough to pass around your body. Cut it carefully and don't tear the paper.



Answers to Crossword Puzzle

(See Page 35)

M	A	G	G	O	T		A	T	R	I	U	M
A		O	A	R		V		B	A	N		A
N	O		S		T	A	D		N		P	M
T	A	P		P	O	L	Y	P		C	A	M
L	T		C		E	V	E		L		M	A
E		P	U	T		E		G	A	S		L
	W	A	T	E	R		A	O	R	T	A	
P		T	I	N		F		A	V	E		S
L	A		N		J	E	T		A		A	T
A	N	D		V	O	C	A	L		S	P	Y
S	T		D		B	E	T		T		E	L
M		P	E	T		S		S	O	B		E
A	N	S	W	E	R		S	E	P	A	L	S

TODAY . . . you can do so many things with photography

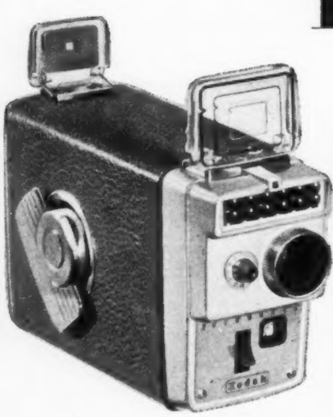
Team up your camera with science projects. Illustrate your notebooks and reports. Prints and slides preserve a specimen long after the original wilts or fades. Ever try processing your own pictures? It's challenging and rewarding.

Analyze the play—with your movie camera. Shoot the team's new plays during practice. Project them for coach and team to study—over and over again. Movies can help polish up teamwork. And they'll become priceless parts of your film library.

Win honors for your photos in Kodak's big $11,750 contest. Pick your best snaps or slides. They can win up to $400. For information and entry blank, write to: Kodak High School Photo Awards, Rochester 4, N.Y. Contest closes March 31, 1961.

Record nature's "small worlds" with camera and microscope. Photomicrography captures the secrets of the structure of a leaf, a hair—anything you see in a microscope. It is an invaluable research tool—and a fascinating way to report a project.

Photography is the



Brownie Automatic Movie Camera, *f*/2.3, sets own lens

You get every vital second with this 8mm movie camera. Built-in electric eye measures light and sets lens automatically while you're shooting. Less than $78, or as little as $8 down. Other 8mm Brownie Movie Cameras, from less than $25, or as little as $2.50 down.

Brownie Starmatic Camera adjusts exposure automatically

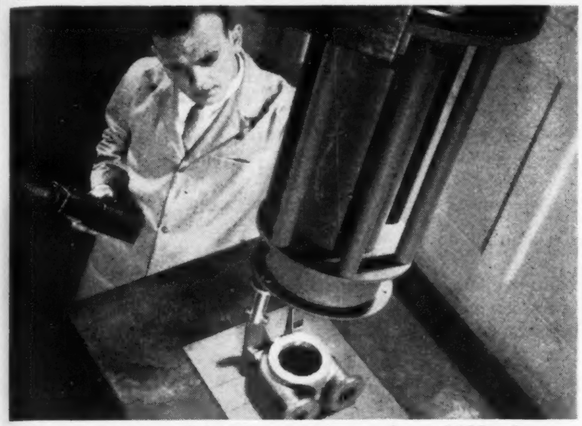
While *you* concentrate on the picture, this automatic camera sets its own lens. For snapshots or slides. Less than $30, or as little as $3 down. Cameras with built-in flash holders: Brownie Starflash Camera, less than $10; Brownie Starmite Camera which uses tiny AG-1 bulbs, less than $11.

Prices are subject to change without notice.

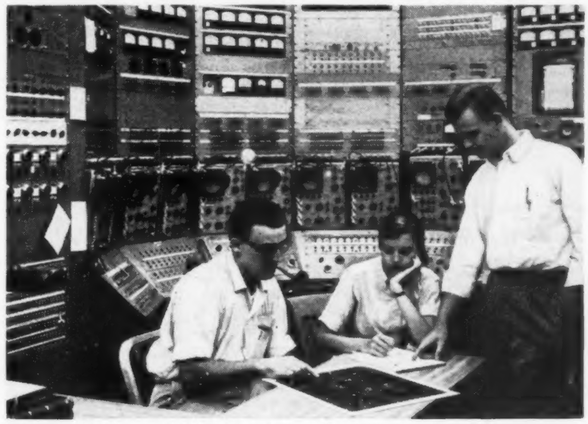
EASTMAN KODAK COMPANY

SEE KODAK'S "THE ED SULLIVAN SHOW" AND

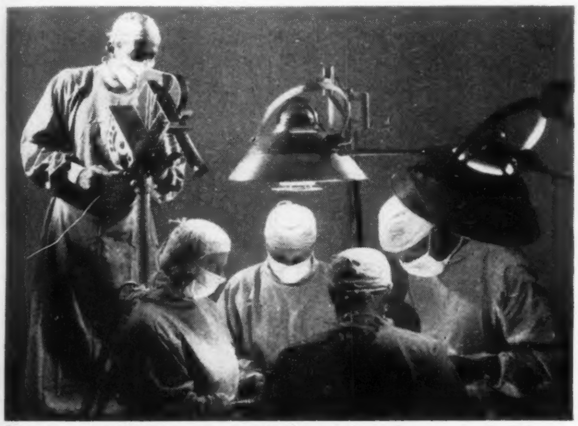
TOMORROW... photography can do so many things for you



Radiography "sees" inside a casting to detect hidden imperfections. With X-rays, or gamma rays and film, engineers can examine a casting for internal flaws such as holes, sand, shrinkage. To be dependable, machines need flawless castings.



Film helps to explain the atom. Because nuclear phenomena occur at such incredible speeds, they can be studied only after they are caught on photographic film. Here, physicists examine the track of particles of antimatter flung from a cyclotron.



Modern medicine has an ally in motion pictures and slides—as well as in radiography. For example, when a camera records an operation, physicians everywhere can "witness" it. Medical photography is used in diagnosis, reporting, teaching.

This "notebook" never forgets a detail. Architects and industrial designers take pictures to remember new ideas and record work in progress. And in the drafting room, photographic reproduction saves countless hours of retracing drawings.

fun with a future!

Kodak close-up lenses and color filters

Make your camera a more versatile scientific tool. Filters let you increase contrast, bring out more detail in a subject. Kodak Portra Lenses enable regular cameras to make frame-filling close-ups of small specimens, only a few inches from the camera. Let your Kodak dealer tell you about these interesting scientific aids.

Use dependable Kodak Film

Kodak makes color and black-and-white films for all popular cameras and many special films for industrial and scientific use.

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"THE ADVENTURES OF OZZIE AND HARRIET"

See your dealer for exact retail prices.

LETTERS

Nuclear Detectives

Dear Editor:

What is the difference between a geiger counter and a scintillation counter?

Jan Hanssen
St. Paul, Minnesota

Answer: Both the scintillation counter and Geiger-Mueller counter are instruments for detecting radioactivity. When the nuclei of radioactive atoms break down, they produce high energy particles and radiation, which can be detected by the counters. The energy of alpha and beta particles and gamma radiation can ionize other atoms and molecules, or they can cause certain atoms to emit light. The Geiger-Mueller counter generally measures or records the ion-producing effect of beta and gamma rays. Scintillation counters record the light emissions produced when particles collide with certain kinds of atoms (usually sodium iodide).

Each instrument consists of three parts: a detector, an amplifier, and a counting or recording device. The detector of the Geiger-Mueller counter is a gas-filled tube through which runs a positively charged wire. It is called a Geiger tube. The inner wall of the tube is a metal cylinder and negatively charged. Wall and wire are separated by an inert gas (helium or argon) under low pressure. If beta or gamma rays enter the gas, they ionize some of the gas atoms, producing an "avalanche" of electrons and leaving positive gas ions. The electrons migrate toward the positive wire and the ions move toward the negative wall. This movement of electrons to one electrode and positive ions to the other constitutes an electric current. It is, of course, a very small current. But it can be amplified to flash a light, click an earphone, or activate a mechanical counter.

Scintillations can sometimes be observed without special equipment. Your watch dial may be luminous because alpha particles from the disintegration of the radium atoms will cause atoms of phosphorescent zinc sulfide to emit a flash of light. A scintillation counter makes use of this effect. In its detector component, some phosphorescent material is used in conjunction with a photomultiplier tube. The photo multiplier converts the light energy into electrical energy. The tiny electrical currents are amplified and made to operate a flashing tube or mechanical counter to keep a score of nuclear events.

Doceo, docere, docui, doctus

Dear Editor:

Many of the scientists I read about in *Science World* are called doctor. I know that they have a degree called Ph.D., but I really don't know what it is or how they get it.

Jim Preston,
Columbus, Ohio

Answer: Although the initials Ph.D. mean doctor of philosophy, very few people who have the degree today have studied philosophy as it is defined nowadays. The name of the degree comes down from the medieval universities where theoretical studies of almost any subject in the curriculum were called philosophy. In fact, right up through the nineteenth century, until 1890, science was called natural philosophy.

Students in medieval times were taught in Latin. Doctor is the Latin word for teacher. When the medieval student earned the title, he was qualified to teach in one of the universities.

Today the Ph.D. and Doctor of Science are the most advanced degrees that can be earned in the sciences. The first Ph.D.'s in America were given at the end of the last century by The Johns Hopkins University, Baltimore, Md., which adapted a graduate program from German universities.

The standard time requirement for a Ph.D. is three years of study beyond college graduation. Excellence and competence rather than time are held to be the criteria. The student is expected to become fairly expert in one field and at least two related fields. He is also expected to learn research techniques and carry out an original research project. At the end of the study and research there is a series of difficult written and oral examinations on the fields of study and the research.

It is not necessary to earn a Ph.D. in order to be a scientist. Only about 40 per cent of scientists in colleges and universities have the Ph.D. degree. But years of advanced study are required. Thus many people who plan a teaching or research career also plan to earn a Ph.D. degree.

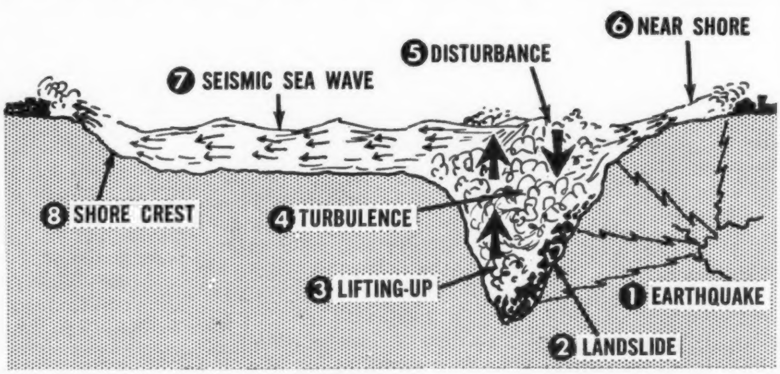
Tsunami Without Numbers

Dear Editor:

What happened to some of the numbers in the drawing on page 10 of the Sept. 14 issue? They were blacked out and literally left me in the dark.

Charles Merkel
Chicago, Ill.

Answer: There's many a byway (and many a slip) between the artist's drawing board and the printing press. Some of the numbers got lost on their way from one to the other. A corrected drawing is presented below.



Science World graphic

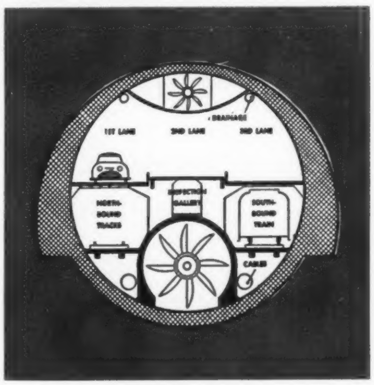
Illustration above is corrected drawing of one which appeared on page 10 of Sept. 14, 1960 issue with some of numbers blacked out. Drawing shows steps involved when tsunami (seismic tidal wave), set in motion by earthquake, crosses ocean at jet speeds. In shallow water, energy of tsunami produces waves of enormous force.

Science PAST...

Imagine the engineering and construction problems involved in building the Tower of Babel (pictured at left) 2,500 years ago when only primitive tools and instruments existed! The entire exciting saga of man's first cultural endeavors unfolds before your eyes in *The Anvil of Civilization,* available this month.

and Science FUTURE...

For more than 150 years, one of man's most ambitious dreams has been to construct a tunnel from Great Britain to France beneath the English Channel. Can it be done? Pictured below is an engineer's sketch of one tunnel possibility, designed for motor traffic and railway trains alike. Willy Ley, world-famous scientist and writer for *Sci-*



ence World, discusses this and eight other fascinating projects in *Engineers' Dreams,* a book that may give you dreams of your own! Details are on the next page.

SCIENCE WORLD BOOK CLUB ***NEWS***

BRAND NEW BOOK CLUB OFF TO A JET START

Science fans! For the first time—anywhere—a book club has been designed especially for you. Six times this school year—right from the pages of *Science World*—you will be able to choose among paperback books keyed to the latest-breaking scientific developments of our time.

MEET YOUR AUTHORS

Martin Caidin, author of this month's *X-15,* has been writing in the field of aviation since he was sixteen. By the time he reached the ripe old age of seventeen, he had published almost 200 articles on science, rockets and atomic warfare. Since then he's written numerous books on missiles and space travel, including one documentary novel. Mr. Caidin lives in New York with his wife and small child. His hobby? You guessed it—flying!

Microbe Hunters, by **Paul de Kruif,** started out merely as background material for Sinclair Lewis's novel *Arrowsmith.* While doing the medical and scientific research, Mr. de Kruif realized that he had the makings of a book of his own! An ardent crusader, de Kruif has written since 1935 to further the spread of preventive medicine.

What's your favorite science — chemistry, physics, electronics? Bacteriology, botany, biology? Astronomy, archaeology, anthropology? Or perhaps space travel and science fiction? Science World Book Club will hit them all!

Each offer will include the widest possible scope in science and related fields. You'll learn not only about scientific discoveries, but about the men and women behind them.

Offer number one—see the following two pages for details—gets off to a jet start with everything from microbe hunting to mathematics. Whether you plan to be a doctor, engineer, space-researcher or science teacher, here's low-cost reading (at discount prices) to help you prepare for the future—and enjoy yourself at the same time!

This Month's Books

Here's a sample of this month's selections:

- *X-15, Man's First Flight into Space*—a visit to the threshold of a new era, with the ship that has just broken all speed and altitude records.
- *Microbe Hunters*—laboratories all over the globe probe the secrets of life and death.
- *One Two Three . . . Infinity*—onetime speculations about the world we live in are proved as facts.
- *The Time Machine*—a scientist is catapulted 800,000 years ahead into the midst of a terrifying civilization . . . fast-paced science-fiction. Plus 16 other adventures in science reading.

Remember, there is no set number of books a member must buy each time; there is no membership fee; you need not order from every offer. The only requirement is that a Club must buy at least 15 books every time it orders. Ask your teacher for details.

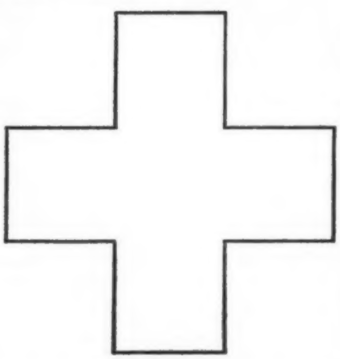
Build up your science library — join Science World Book Club!

Can You Solve This?

Here's a teaser called "Puzzle Without a Number," from *Magic House of Numbers,* a Science World Book Club selection.

Cut out a piece of cardboard in the shape of the cross shown at right (draw a square and then attach an equal square to each of its sides). Now make four straight cuts that divide the cross into five pieces that can be arranged to form a square.

Can you solve it? The answer is in your teacher's edition of *Science World.*

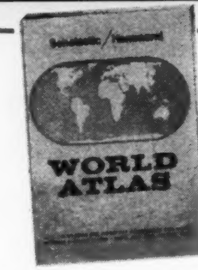


SCIENCE WORLD BOOK CLUB *NEWS*

Start stocking your science library now—
at discount prices—with the 20 selections
pictured on these two pages. Boost your
grades, prepare for the future, and enjoy
the best science authors writing today!

***X-15—MAN'S FIRST FLIGHT INTO SPACE —Martin Caidin**

Meet the men making record-breaking flights into space. Sit with them behind the controls of the world's first spaceship—the *X-15*. Watch them undergo the body-punishing pre-flight tests; meet their families, learn the dangers that await them beyond our atmosphere. Photos on almost every thrilling page! **25¢**

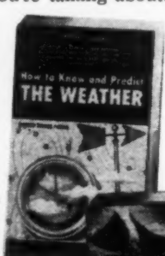


***SCHOLASTIC/HAMMOND WORLD ATLAS**

Up-to-date maps of all countries of the world — plus the living story of maps, globes and the part they play in the world today. Also, map facts on how to read projections . . . what contours are and how to use them . . . dozens of full-color drawings. An invaluable look-it-up book for all — and bargain priced! ~~35¢~~ **30¢**

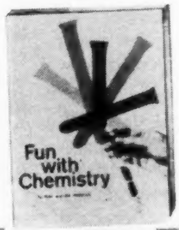
HOW TO KNOW AND PREDICT THE WEATHER — Robert M. Fisher

No matter how good a weather prophet you are, here's your chance to improve! What causes hurricanes . . . heat waves . . . clouds, rain and fog? Here are illustrated answers to these and many other puzzlers. Interesting reading; helpful with school work, too. Everyone talks about the weather—here's a way to know what you're talking about! ~~50¢~~ **45¢**



***FUN WITH CHEMISTRY — Mae & Ira Freeman**

Want to write a secret message chemically? See fire produce water? *Watch plants breathe?* Here are 28 easy chemistry experiments using simple materials. Pictures show you how. Have fun—*and* learn strange, exciting scientific facts you can prove to your friends. (*P.S.* You can do it all in your own home.) **25¢**

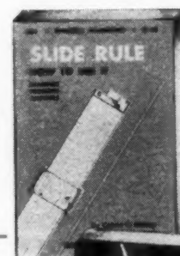


THE TIME MACHINE — H. G. Wells

Trapped by cannibals — and he's 800,000 *years* from home! Ride with the Time Traveler into the future. Meet the frail, pathetic *Eloi* . . . the clammy, ghostlike *Morlocks*. The Time Traveler learns that he's dealing with man-eaters—and then his Time Machine is stolen! All-time S-F great, by the author of *The Invisible Man*. Also a hit movie! **25¢**

SLIDE RULE — HOW TO USE IT —Calvin C. Bishop

Simple, practical — *fully illustrated* guide to proficiency with this indispensable tool. Complete explanations and charts show exactly how to set and operate all the most popular types of rules. More than 200 problems develop speed and accuracy. Here's a book you'll keep handy till the end of your college days! ~~$1.25~~ **$1.10**

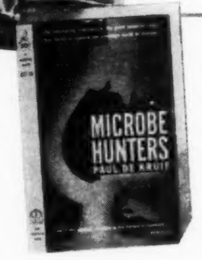


THE CRUST OF THE EARTH — Rapport & Wright

How was the earth born? What causes volcanic eruptions? What will happen when our oil and fresh water resources are used up? How long will the earth remain habitable? Here's the background you need for understanding current investigations of the earth's crust — including the fabulous Mohole Project. ~~50¢~~ **45¢**

ENGINEERS' DREAMS — Willy Ley

Great projects that could come true in your lifetime: a tunnel beneath the English Channel . . . harnessing the power of the sun, wind *and live volcanoes* . . . man-made islands in the middle of the ocean! A famed scientist and writer for *Science World* tells about nine fantastic engineers' dreams—some of which are being planned right now! ~~$1.25~~ **$1.10**



MICROBE HUNTERS — Paul de Kruif

One of the great best-sellers of modern times — 13 scientific pioneers challenge the terrors of the unknown . . . and win! Learn how the dangers of diphtheria, malaria, yellow fever and other killers were conquered by raw determination and fearless exposure to these dread diseases. Dramatic and inspiring episodes—all true! ~~35¢~~ **30¢**

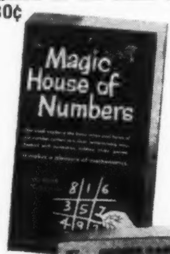
THE AIR FORCE BLUE BOOK —Tom Compere, ed.

The Air Force is up to its wings in science—just look at today's headlines—and here's the book that shows you where you can fit in and be well on your way to a career in science. Crammed with 382 pages of text and photos, it covers everything from our newest electronic sentinel to the drama of a countdown. Special, low-priced Club edition! ~~50¢~~ **45¢**

**Recommended for General Science Students*

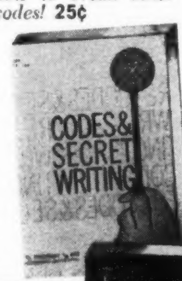
*MAGIC HOUSE OF NUMBERS
— Irving Adler

Have fun with numbers — and pick up dozens of handy short-cuts to help you in math! Clear and simple methods of counting, dividing and multiplying . . . card tricks, mathematical riddles and curiosities, number games and puzzles. Learn the whole basis of our ten-scale number system—and be entertained at the same time! ~~35¢~~ **30¢**



*CODES AND SECRET WRITING
— Herbert S. Zim

Devise your own code wheels . . . know when to use alphabetical, cipher, symbol and position codes . . . Make your own invisible ink (ten different kinds, with their developers!). Dr. Zim, a well-known expert, teaches *you* how to become a code expert *and then tells you how to break other people's codes!* **25¢**

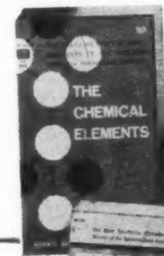


ELEVEN BLUE MEN
— Berton Roueché

Eleven men collapse, *then turn blue all over* . . . a nightmarish fog strikes down half a town's population . . . deadly tetanus kils six and is then tracked to a common source! See doctors turn detective to corner elusive killers. Here are twelve medical "whatdunits" that will keep you on the edge of your seat—all true stories! **25¢**

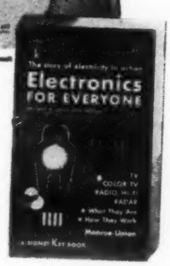
THE CHEMICAL ELEMENTS
— Helen Miles Davis

How many chemical elements are there? No one knows! This mystery is one of the most spellbinding *unfinished stories* in the physical universe. Read how scientists are prying loose the answers with cosmic rays and giant accelerators . . . how the blank pages in the Periodic Table are being filled by atomic research. Ideal chem handbook. ~~50¢~~ **45¢**



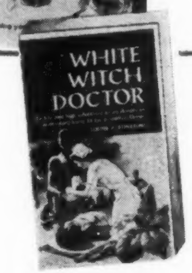
ONE TWO THREE . . . INFINITY
— George Gamow

Can space be "bent"? How do you count an infinity? Why does a rocket shrink? George Gamow—world renowned scientist—takes you on a stimulating adventure into the wonderland of scientific fact and theory. Includes brain-teasing questions of numbers, excursions into the fourth dimension, much more. With over a hundred illustrations! ~~50¢~~ **45¢**



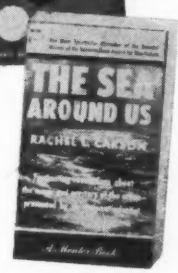
ELECTRONICS FOR EVERYONE
— Monroe Upton

Engrossing story of man's conquest of "our most revolutionary science." From important fundamental discoveries in the field to the fascinating story of man's conquest of the versatile electron. "Must" reading for hi-fi fans as well as physics students. Highlighted by more than 100 drawings. ~~50¢~~ **45¢**



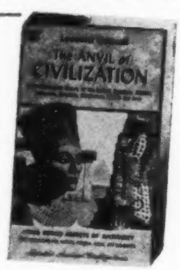
WHITE WITCH DOCTOR
— Louise Stinetorf

Adventure was Ellen Burton's specialty, but she got more than she bargained for as medical missionary deep in the Belgian Congo. Exciting story of love, danger and excitement in a country where a shotgun was worth a fortune, and a tin can would buy a wife! Fact-based fiction from the African jungle. ~~35¢~~ **30¢**



THE SEA AROUND US
— Rachel Carson

From the centuries of ceaseless rainfall that created the sea, and from the sea's own millenniums that created the first life, Rachel Carson traces the strange links of the sea and its life to our own. A modern classic—winner of the National Book Award, and a distinguished addition to every science library. ~~50¢~~ **45¢**



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— Leonard Cottrell

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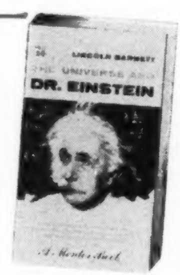

THE UNIVERSE AND DR. EINSTEIN — Lincoln Barnett

Here's "the best account yet written" of the new era ushered in by Einstein's discoveries. In the entire history of the world, few men have revolutionized human thinking as did this physicist-genius. An understanding of his lifework is a *must* for all serious science students. (Note: also included: the latest nuclear discoveries!) ~~50¢~~ **45¢**

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- ☐ Universe, Dr. Einstein—45¢

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Recommended for General Science Students

Virus Hunter

(Continued from page 20)

Now what is the relationship between a virus and disease?

The first virus was identified in 1935. Since then, some 300 viruses have been found. An isolated virus does not even resemble a living organism. It is a tiny particle made up of two chemical substances—protein and nucleic acid. The protein is a coat around the acid. Extracted in a pure state, viruses do not move or reproduce. Inside a living cell, however, viruses come alive, begin to multiply, and reproduce their characteristic structure.

But how do viruses get inside a cell?

They enter the body through cuts or in food. The blood carries them past various cells until they meet cells they are capable of "attacking."

The attack begins when the protein outer coat "punctures" the cell wall. Then the core of the virus, a large molecule of nucleic acid (DNA), is injected into the cell. The protein outer coat is left outside the cell. In as little as one tenth of a second, a virus can inject itself into a cell.

The Virus—Deadly Parasite

The polio virus is one of the smallest of all viruses. One million polio viruses lined up side by side would equal an inch in length. They are spherical in shape. Sixty identical units of protein are arranged like the seeds of a raspberry around a core of nucleic acid. The nucleic acid molecule is made of two spiral strands coiled around each other.

The protein coat of the polio virus is capable of "puncturing" the membrane of nerve cells. As soon as the nucleic acid passes into the nerve cell, it begins to multiply, destroying the cell in the process. The coiled strands separate and begin to mold other coiled strands. In a few hours, about 100,000 new viruses are formed.

When the virus invades a body cell, it does not reproduce as bacteria do—by splitting. The most recent hypothesis is that the virus "takes command" of the cell and uses its materials to develop a new colony of viruses. No one knows yet how each new virus is able to construct a protein coat identical to the original one left outside the cell. It is believed that the key to this phenomenon lies in the nucleic acid.

As the viruses multiply, they spread to neighboring nerve cells. When most of the nerve cells serving a part of the body are destroyed, paralysis occurs.

The problem for polio vaccine developers: Find a type of polio virus which cannot destroy nerve cells, yet can stimulate formation of antibodies.

Dr. Jonas Salk developed his vaccine using a *killed* virus. Since killed viruses cannot multiply, no nerve cells are destroyed when the viruses are used for antibody production.

Dr. Sabin chose another method of obtaining a harmless form of the polio virus for use in a vaccine. He suspected that the laws of heredity would produce a form of the virus that can live in the body without attacking nerve cells. With the backing of the National Foundation, he grew generation after generation of the polio virus in his laboratory. At last he found an attenuated (weak and harmless) form. This attenuated live virus grows well in the human intestine. It also makes its way into the blood stream and stimulates antibody formation. But it never causes paralysis.

The live virus vaccine can be taken by mouth. The harmless viruses live and multiply in the intestine indefinitely, giving life-long protection against the dangerous virus form. The harmless virus can be "caught" by people in close contact with each other. In this way the immunity can spread throughout a community.

The apparent lateness of the Public Health Service's approval of Dr. Sabin's vaccine was due to caution in testing the harmless live virus. Some scientists felt that the harmless virus may, in its passage from person to person, revert back into the dangerous form. Dr. Sabin is not worried about this possibility. So far, carefully controlled experiments show this is unlikely.

Next Project—Cancer

Dr. Sabin modestly considers research his "hobby," and feels his "principal achievements" are his daughters—Deborah, 10, and Amy, 8.

In his spare time Dr. Sabin enjoys listening to music, which helps him to "recharge the mental batteries."

"My work on the polio vaccine is over," Dr. Sabin told us, "and I have already turned my attention to cancer research."

Good luck, Dr. Sabin!

—WALTER CARROLL

Hello, Out There

(Continued from page 26)

we have mapped our galaxy and those beyond by using the 1420 mc radio wave radiation from excited hydrogen. Is this the frequency that we should use for *our* exploration?

If living creatures elsewhere in the universe were as developed as we are, they too would probably have discovered radio astronomy, and they too would have discovered the uniqueness of the 1420 mc radiation of hydrogen. Suppose we were to set up a transmitter with a power of one megawatt per cycle operating at the 1420 mc frequency. To the radio astronomer on a distant planet, the Earth would "shine out" almost a million times brighter than any other single object in our section of the heavens.

If we added an intelligible signal to our radio wave, our distant friend could be certain that intelligent beings existed elsewhere in the universe. Perhaps just such a transmitter is being built or is operating at this very moment on some obscure planet of a distant star!

Questions

1. Should we first set up receivers and listen on the 1420 mc frequency, and then, after listening for 50 to 100 years, begin transmission—or should we do it the other way around?

2. What signals should we transmit that will assure recognition by intelligent beings?

3. Presuming that we establish radio contact with a life form beyond the solar system, what possible dangers could arise? What advantages?

4. How could we most quickly ascertain whether a distant civilization is advanced scientifically beyond ours? (Remember it may take 100 years for replies to questions we might ask!)

Answers

1. Project Ozma (on which the passage is based) has chosen to receive first.

2. The suggestion has been made that we transmit a series of cardinal numbers (1, 2, 3, 4, . . .) or prime numbers (1, 3, 7, 13, . . .).

3. Since the likelihood of hurling matter across the intervening space is not very great, war as we know it would not be possible. All that could be exchanged is knowledge.

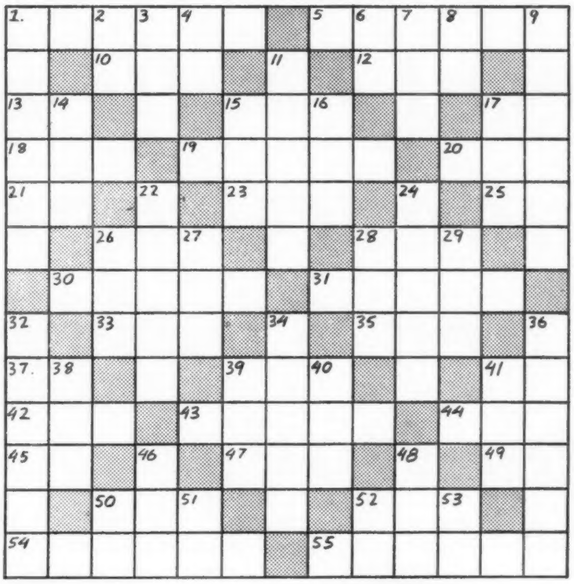
4. One suggestion is that we transmit what is known as the fine structure constant of hydrogen (137.062). We know this number to 3 decimal places. If we receive in return the number with additional decimal places, we shall know that their understanding of the quantum theory is beyond ours.

Biology Roundup

By Cheryl Sarandrea, Villa Joseph Marie High School, Newtown, Pa.

★ Starred words refer to biology

Students are invited to submit original crossword puzzles for publication in *Science World*. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include symmetrical puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzles cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, New York. Answers to this puzzle are on page 27.



ACROSS

• 1. Larva of certain insects.
• 5. Any of various cavities or chambers; esp. auricle of the heart.
10. Used with a rowboat.
12. Forbid.
13. Negative answer.
•15. The ______pole phase is part of a frog's life cycle.
17. Hours after noon (*abbr.*).
18. Strike lightly.
•19. Tube-shaped water animal.
20. Changes rotary motion to linear.
21. Lieutenant (*abbr.*).
23. Adam's wife.
25. Former name of element 43 (*symbol*).
26. To place.
•28. Anaerobic bacteria may produce ______.
30. H_2O.
•31. Great artery which carries blood from heart to body.
33. Element number 50.
35. Automatic volume expansion (*abbr.*).
37. Lanthanum (*chemical symbol*).
39. High-speed stream of hot gases.
41. Near to.
42. Rock ______ roll.
•43. ______ cords are located in the larynx.
44. Secret agent.
45. Street (*abbr.*).
47. Gamble on probability.
49. Inventor of cyclotron (*initials*).
50. Animal kept for pleasure.
52. Weep in gasps.
54. Whatever you reply.
•55. Outer leaf-like parts at base of flower.

DOWN

• 1. Outer covering of soft part of clam.
2. When traffic lights turn green, you ______.
• 3. Matter that lacks fixed shape and volume.
4. Conjunction meaning *either*.
• 6. Disease caused by tubercle bacillus (*abbr.*).
7. Moved rapidly.
8. If you're not out, you're ______.
• 9. Vertebrate that nurses its young.
•11. Shell of clam.
14. Edible grain.
•15. Phalange of human foot.
•16. Substance used to bring out detail in cells.
17. Nickname for *Pamela*.
•22. Covers epidermis of a leaf.
•24. Worm-like stage of insect development.
26. Beat lightly.
27. Basis of decimal numbers.
28. Portuguese territory in India.
29. Female saint (*French abbr.*).
•32. Amber-colored liquid found in blood.
•34. Waste material.
•36. Stalk-like parts of pistil.
•38. Small social insect of hymenoptera order.
39. A book of the Old Testament.
40. To make by tatting.
•41. Large tailless Old World monkey.
46. Water droplets condensed on cool surfaces.
48. Toy made to spin.
50. Postscript (*abbr.*).
51. Tellurium (*chemical symbol*).
52. Element number 34.
53. Barium (*chemical symbol*).

Sci-fun

"Mr. Twiggle, if you please, we refer to the 'Rana Catesbeiana' as 'frog,' not 'hoppy-toad.'"

"That new plane is sure fast! I flew to the West Coast this morning, and arrived there yesterday!"

"Now for tomorrow's weather and the explanation of what went wrong with yesterday's forecast."

Using Science World

(Continued from page 10-T)

3. "Today we know that the nuclear force between two particles is negligible if the distance between the particles is more than four fermis." (a) How do we know? (b) What is a *fermi*? (c) What is the diameter of the hydrogen atom?
4. How did Yukawa's particles come to be named "mesons"? Explain the relationship between mesons, on one hand, and protons and neutrons, on the other.
5. By what methods was the actual existence of Yukawa's particles discovered? Why were they renamed pi-mesons?
6. Describe the methods being used by atomic physicists at the present time in studying atomic forces.

Today's Scientists—Dr. Albert Sabin (p. 20)

Biology Topics: Immunity, microparasitism, viruses, disease prevention.
Vocational Guidance: Microbiologist

About This Article

A number of points in the life story of this celebrated investigator deserve emphasis. He rose from humble beginnings in a poor immigrant family—a tribute to America as a land of opportunity. His life was profoundly influenced by a book; the reading of Paul de Kruif's *Microbe Hunters* turned the young dentistry student to microbiology. This last point should impress teachers with the potential they have for influencing the lives of their charges. Once started in polio research, Dr. Sabin was ticketed for 25 years of persistent effort that led to his becoming a benefactor of all humanity.

Students reading this piece will also gather some significant information about immunity, the biochemistry of viruses in general, and they will learn how viruses attack larger microorganisms and the cells of multicellular plants and animals. The following review questions are based on the biology content of this article.

Review Questions

1. When was the first virus isolated.
2. How many different kinds of viruses have been isolated to date?
3. How does a virus get into a cell?
4. How does the polio virus get into a nerve cell?
5. How does the polio virus multiply once it enters the nerve cell?
6. Contrast the Salk vaccine with the Sabin vaccine.
7. What are some advantages of the Sabin over the Salk method of polio control?
8. Why was the use of the Sabin vaccine so long delayed?

Tomorrow's Scientists (pp. 21-24)

Utilization of Cornstalk Waste

Absorbent paper, cardboard, insulating board, packing material—all from old cornstalks that would otherwise go to waste; this is the theme of David Schubert's chemistry project. "It is possible," states David, "to produce board of almost any desired quality." He can even produce a flower pot that decays in the soil and is eventually used by the plant that grew within it.

From his paper-making, David went on to produce rayon fiber and furfural, a solvent useful in dyes, as a weed killer, and for treating seeds to eliminate parasitic fungi. From this young scientist's work it is evident that industry may well turn from trees to corn stalks to satisfy its ever increasing need for cellulose.

Teaching Suggestions

David's project-report may be assigned as reading in the chemistry class to supplement the usually meager treatment given to the compounds of carbon in most elementary textbooks. The report may also be used to illustrate to a class the general principle to be kept in mind in writing a scientific paper; namely, that procedures must be described in such detail that a reader could repeat them to verify the observations being reported.

Life Cycle of Coturnix, A New Laboratory Animal

For her project, Sarah Johnson has made a photographic record of the embryonic development of the Japanese Quail, *Colinus coturnix japonicqa*. While her project is observational rather than experimental, it is nevertheless interesting. It can serve not only to introduce students to the Germfree Research Center at Tampa, Florida, but also to introduce biology students to a bird whose life history and other characteristics make it a potentially useful organism for laboratory experiments.

Demonstrations and Experiments

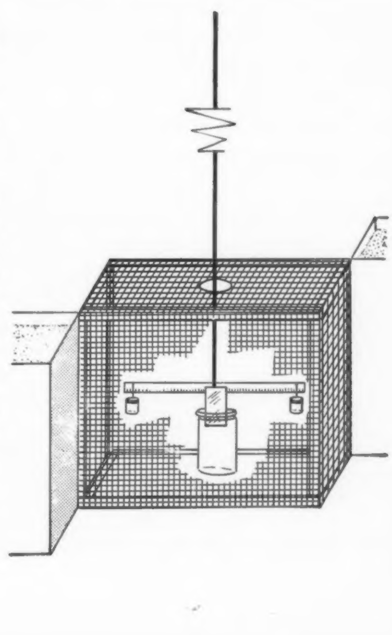
Nothing is more effective in stimulating interest and instilling an understanding of scientific principles than a well-designed classroom demonstration. In this new department, *Science World* will present modern demonstrations, making use of the latest techniques and materials. Each of these demonstrations has been developed by science educators. Each is designed to supplement major articles appearing in *Science World*.

Measuring Earth's Gravity

Photograph a falling ball by spinning a strobe disk in front of a camera lens with the shutter open. Or use the same equipment to photograph the free fall of a flashlight bulb soldered to a flashlight battery. Drive the stroke disk with a small synchronous (clock) motor. If you know the rpm of the motor, you can obtain "g," the acceleration of gravity, from the data in the photograph.

A large scale version of the famous Cavendish apparatus can be made by suspending a yardstick from a double thickness of magnetic recording tape about 20 feet long. The yardstick is balanced and the tape hung from a support in a gym or high-ceilinged room with a concrete floor. The support must be free of vibration. At each end of the yardstick, hang a three-ounce bottle of water and balance once more. Make a large rectangular frame of wood, 4 ft. long, 2 ft. high, and 2 ft. wide. Cover this frame on all sides with metal win-

(Continued on page 14-T)



Demonstrations

(Continued from page 13-T)

dow screening and set it on the concrete floor. Make a hole in the top of the screen for the tape to pass through. Glue a mirror at the center of the yardstick and rebalance. The bottom of the mirror should move in a jar of water to damp the motion. Next shine a narrow beam of light on the mirror. By covering a focusing searchlight lens with black tape so that a 1/8" slit remains, you will have a narrow beam source. Aim the beam at the mirror from a distance of three feet. Pick up the reflected beam on a large card about 20 ft. away. This will give you great amplification of the motion.

Now to perform the experiment. Place large boxes of sand flush against diagonally opposite corners of the apparatus. Ground the window screening and the top of the long tape. This will ground out any electrostatic charges which produce forces greater than that of gravitational attraction. Watch the light beam swing slowly across the large card. The period is very slow—about 30 seconds per swing. If you change the material in the boxes from sand to dry sawdust (with a lower mass) the period of swing will be longer, indicating a lessened gravitational attraction.

Light and Life

Construct boxes so that one side of each box is made of glass or plastic covered with layers of colored cellophane as color filters. Place identical plants inside the boxes and compare the growth under different colors (wave lengths) of light, over a long period of time.

To extract chlorophyll safely without possibility of fire resulting from ignition of alcohol by a Bunsen flame, use a small electric immersion heater of the type sold for heating water in a cup for coffee or tea. First boil the leaf to be studied in water. Remove the water and boil in alcohol. When the alcohol turns green you are ready to separate the chlorophyll A from chlorophyll B and the xanthene.

After the extracted chlorophyll has cooled, place an eight-inch strip of Wratten filter paper or chromatograph filter paper so that one end is in the center of the mixture. The other end is supported vertically. After some time this simple chromatographic strip will show three different horizontal lines where the three compounds have separated because of the different rate of mobility of each kind of molecule. The xanthene will be yellow-orange and there will be a green line for chlorophyll A and another for chlorophyll B.

The "Glue" of Matter

In addition to the projects with the cloud chamber described in Project Pointers *(p. 25)*, you can show that a charged electroscope is rapidly discharged if a radioactive source is brought near the electrode of the electroscope. You may want to show that gamma rays will affect photographic film contained in lightproof holders.

The easiest way to demonstrate this is to borrow a few dental X ray films (unexposed) from a dentist. Over the front of the covered film place a piece of mantle used in gas lamps or in Coleman gasoline lanterns. These mantles are made of asbestos or nylon thread impregnated with thorium oxide. Thorium is listed in the radioactive series in the atomic table.

Expose the film for a week. Then develop the film or ask the dentist to do it for you. The pattern of the mantle weave will appear on the film. You can repeat the experiment with a small key held against the film and the mantle placed over the key. If you allow a week for exposure and then develop the film, it will show an outline of the key. Samples of thorium and uranium ores can also be used for this experiment.

When the film is developed and dried you can mount it between 2" x 2" slide glasses, bind it, and project it on the classroom screen with a 2" x 2" slide projector.

Life Cycle of Coturnix

If students want to study the embryology of birds, the simplest way is to incubate chicken eggs. The incubator can be a carton fitted with a base mounting light socket. The socket is wired in series with an ether-wafer thermostat. Also place a laboratory thermometer through a small hole in the carton wall so that you can read the temperature. Adjust the thermostat to maintain about 103° F. Examine a new incubating egg every day.

FSA PROGRAMS AND AWARDS

Science World Committee

Arrangements for continued close association between the National Science Teachers Association and *Science World* will be continued in 1960-61. *Science World* will continue to carry Tomorrow's Scientists with projects and news of Future Scientists of America activities. During the past year, NSTA has been represented on the *Science World* Editorial Board by the following committee: Sam S. Blanc, Gove Junior High School, Denver, Colorado; Anne E. Nesbit, South Junior High School, Pittsfield, Massachusetts; and Stanley W. Williamson, Oregon State College, Corvallis, Oregon.

Youth Conference on Atom

The second annual Youth Conference on the Atom will take place in Chicago, October 20-22, 1960, at the Museum of Science and Industry. Student scientists from 38 states will convene to study the atom as it is used in a myriad of peaceful applications and as a frontier of science. Students taking part will be chosen from among the nation's brightest youths through science fairs, examinations, and by leading educators.

Sponsored by 62 electric light and power companies and co-sponsored by the National Science Teachers Association and the Future Scientists of America Foundation, approximately 250 students, accompanied by their science teachers, will participate in the three-day conference. Students and teachers will be addressed by some of America's foremost scientists and will take part in group discussion sessions with scientists from the Argonne National Laboratory, the University of Chicago, and the Illinois Institute of Technology.

FSA Awards

For the tenth consecutive year, NSTA is conducting a student science awards program dealing with projects prepared by young people in grades seven through twelve. Formerly known as the Science Achievement Awards for Students, this program will henceforth be called Future Scientists of America Awards (FSAA). To expedite fairness of competition and equality among states, a system of eleven geographical regions has been established within the United States. Similarly, there are three category divisions according to grade level: grades 7-8, 9-10, and 11-12. In this manner, a seventh-grade student will not be compelled to compete with a twelfth-grade student or even with a ninth-grade student. With revision of the program, there have been some internal changes. For example, the national metals and metallurgy award has been eliminated.

Materials for the 1961 FSAA are currently available and may be obtained by writing to the Future Scientists of America, NSTA, 1201 Sixteenth St., N. W., Washington 6, D. C. Teachers are urged to request materials for not more than ten per cent of their students.

FUTURE SCIENTISTS OF AMERICA

The first year of the 1960 decade promises to be a momentous one for the National Science Teachers Association—in fact, for all "science-prone" students and their teachers. The Future Scientists of America (FSA) program will be inaugurated this month.

The FSA youth program with its services to teachers and club activities for students is an ambitious undertaking for the NSTA. Science teachers throughout the United States responded to a questionnaire and opinionnaire circulated by NSTA asking for help in establishing directions and making decisions about this new youth organization. The results proved to be favorable.

In the summer of 1959, having compiled the advice and experiences of over 2,000 scientists, science educators, science teachers, supervisors, superintendents, and other interested persons directly connected with education and youth organizations, the NSTA Board of Directors approved the general plan for an FSA program. At this meeting also, the appointment of a Director of Youth Activities was authorized. Mr. William P. Ladson joined the NSTA staff on February 15, 1960, in this capacity. Mr. Ladson was formerly head of the Science Department at Groveton High School in Fairfax County, Virginia, and has a wide background of association with youth activities, professional organizations, and science institutes.

The Future Scientists of America Foundation Administrative Committee and the NSTA Board of Directors authorized Dr. Zachariah Subarsky, Coordinator of Special Science Activities at the Bronx High School of Science in New York City, to guide the preparation of an operational plan for the Future Scientists of America. At the Board of Directors 1960 annual meeting in Los Angeles, California, the specifications for the operation of a Future Scientists of America program under the auspices of NSTA were authorized.

Youth Activities

The initial offerings of FSA will include:

The chartering of school science clubs as chapters of FSA.

A sponsor's guide for teachers containing suggestions for operation of an FSA chapter and appropriate related activities.

A quarterly newsletter published by the National Science Teachers Association for FSA, containing news and describing work that is taking place in the FSA chapters.

A chapter charter or plaque for the school, and membership cards, pins, and other insignia for students.

A "Vistas in Science" series of paperback books, each consisting of a historical review, an approach to research, and a student project section within a particular science discipline.

Suggestions for the operation of a youth science congress in which students meet to present papers about work they have accomplished individually during the year.

Many other activities are contemplated for the evolving FSA program. These may include, for example, the production of career guidance films, a U. S. Youth Registry for Achievement in Science and Mathematics, and possible summer conferences for FSA student leaders.

The Youth Registry would be an accumulation of names of outstanding science students throughout the United

States based on state, regional, or national achievement, or those who have been recognized as highly capable students. For example, a student selected for one of the National Science Foundation summer institutes would be eligible for placement on the registry. The reason for establishing such a registry is that it will produce a reservoir of identified science talent correlated with extracurricular activities and achievements in science. Another main objective is to identify meritorious students for admissions officers of colleges and universities offering special programs or scholarships.

A group of science teachers, science educators, supervisors, superintendents, and other interested persons have been drawn together as the Field Advisory Board (FAB) to aid in establishing plans and ideas for the future expansion of the FSA. The Field Advisory Board now has 150 members.

Through student activities, services, and materials for teachers, FSA aims to assist teachers in locating and nurturing students who have the potential to become productive in the scientific endeavor. FSA will cooperate in every possible way with all existing science programs such as state junior academies of science, state talent searches, and summer institutes for high school students.

Chapter Affiliation

The cost of affiliating an FSA chapter will be based on the total enrollment of the school which supports the chapter. Two or three small schools may find it desirable to cooperate in forming and sponsoring a single chapter of FSA. In some instances, even a group of interested students may participate outside of school if responsible adult leadership can be found. Larger schools, of course, will have their own chapters.

The initial chartering fees for various categories of school populations are as follows:

0-300	$5
301-1000	$8
over 1000	$10

The yearly charter renewal fees are:

0-300	$2
301-1000	$3
over-1000	$4

These fees were established after considerable study of the cost patterns of other comparable youth organizations and on best estimates of actual costs to NSTA of providing the projected FSA services and materials.

The FSA is ready to go. All of the organizational preparations and procedures have been accomplished. The materials and services to assist you in your task of locating and nurturing the interested and motivated students into science fields have been prepared. The FSA program was designed by science teachers, and will be improved through the suggestions of science teachers. NSTA urges science teachers to offer constructive criticism about the program, its administration, services, and materials. NSTA says: "We can assist you only when we are aware of your desires regarding this program. The success of FSA depends on the enthusiasm of you, the science teacher."

Teacher Star Awards

The National Science Teachers Association will not sponsor a STAR Award program for teachers in the 1960-61 school year. In the past the STAR awards programs were conducted by NSTA under grants from the National Cancer Institute. The Association hopes to continue the program in alternate years. This announcement is made to forestall the large number of inquiries received at NSTA headquarters in the "off years."

Dr. Roman Vishniac To Film "Living Biology" Series

Dr. Roman Vishniac, one of the world's leading photographers of microscopic life, will produce the first part of a series of educational films entitled *Living Biology*, under an initial National Science Foundation grant of $112,340 awarded to Yeshiva University.

The 18-month grant will cover production of eight 28-minute films for use by secondary schools and five 45-minute films for colleges and universities. All will be 16 mm. sound-color films.

These thirteen films are only the first part of a larger program. The complete series will include 40 films, 24 for high school use and 16 for college use. It will take three and a half years to complete.

The purpose of the films is to help improve instruction in biology in secondary schools, colleges, and universities. Through the films, students will be able to experience as closely as possible the experiences of original observers in studying organisms in their natural environments.

The Audio-Visual Center of Yeshiva University and the Film Library of the University, will promote and distribute the *Living Biology* series, with direction by the National Science Foundation.

Films in Nine Areas

The *Living Biology* film series will center around nine major areas. These are: Units of Life (protoplasm and cells); Structure and Function of Organisms (organs, systems, etc.); Growth and Development (embryology); Origin of Life (evolution); Heredity (genetics); Structure and Function of Nature (ecology); the Plant World; the Animal World; and the Microbial World.

The actual photography will be done on location—in those geographical areas which are the natural habitats of the living organisms to be studied. Among the locations expected to be used are Jamaica, B.W.I.; Woods Hole, Mass.; the Scripps Institute, La Jolla, Calif.; Friday Harbor, Wash.; the Aquarium of Miami University, Coral Gables, Fla.; Fish and Wild Life Marine Laboratory, Maine; and the Marine Laboratory, Bermuda.

Dr. Vishniac will consult with leading biologists and members of the National Association of Biology Teachers concerning each of the films.

Biology teachers and research biologists believe there is a need for biology films which can stimulate the imagination and scientific reasoning of students as well as arouse the interest of the general public. Most films prepared for school and college use are designed as supplementary illustrative material. In the Vishniac films the approach and emphasis are different. The *Living Biology* films will come as close as possible to duplicating the experiences of a trained observer engaged in biological research. Thus the student can see for himself the life processes from which current theories evolve.

Organisms Move Normally

Dr. Vishniac's pioneering work in cinematography involves the use of transmitted oblique and semivertical illumination. In his experience, these lighting techniques produce results superior to those of conventional—direct or phrase-contrast—lighting of the internal details of organisms. Whenever possible he uses immersion lenses in preference to conventional flat-mounts between slide and cover slip. This method permits the organisms to move normally and emphasizes their three dimensional aspects. Organisms are revealed in a completely relaxed state within their natural environment. Dr. Vishniac's lighting preserves natural colors that are usually destroyed in conventional microscopy by transmitted light, reflections, and glare.

Dr. Vishniac has produced many biological films for Encyclopaedia Britannica Films, Warner Brothers-Pathe, and Horizons of Science. He looks upon this forthcoming series, announced three days after his 63rd birthday, as the high point of his career.

"For many years I have worked always in anticipation that someday I would succeed in getting the assignment that would permit me to work together with biology teachers, with scientists," he observes. "The most important thing for us today is education. This is the only way we can save the future generations.

"I also believe that education can only be done and must only be done through teachers," Dr. Vishniac continues. "We cannot use any substitutes, no teaching machines, or films that make the teacher completely unnecessary because the movie explains everything and because the narrator is replacing the teacher, looking at the students, and saying what the textbook says. I don't believe that this is the filming approach and I don't believe that the teacher can be substituted for. We need good teachers."

Dr. Vishniac was born on Aug. 19, 1897 near St. Petersburg, Russia. He holds the Ph.D. degree in zoology from Shanyavsky University, Moscow. Dr. Vishniac did research in endocrinology and also holds the M.D. degree from Moscow University. He fled Russia in 1920, via Latvia, and lived for 19 years in Berlin, Germany.

While in Berlin he did post-graduate work in oriental art at the University of Berlin, completing work necessary for a Ph.D. While in Berlin he also continued his biological research, made a study of optics and the behavior of light, and worked as a portrait and journalistic photographer.

In the late 1930s, portents of the approaching Nazi regime sent Dr. Vishniac on a series of expeditions to photograph the faces and lives of Jews in Eastern Europe. A selection of these pictures, published under the title "Polish Jews," has been widely hailed.

Dr. Vishniac came to the United States in December, 1940. After devoting time to a career as a still photographer, he was able to apply his talents to microscopy and scientific cinematography.

He has pioneered time lapse technique in cinematography since 1924. He is former president of the New York Entomological Society; fellow of the New York Academy of Sciences; fellow, Royal Microscopical Society (England); fellow of the Biological Photographic Association; and member of the American Society of Zoologists.

He received, in 1956, the Memorial Award of the American Society of Magazine Photographers for "showing mankind the beauty of the world it cannot see." He also won the Grand Prize in Art in Photography at "Art in U.S.A.: 1959."

Teaching Materials Roundup

Magnifier—Gadget or Tool?

Have you considered using a hand lens for a lesson or a series of lessons?

A magnifier is just as much a small tool as is a micrometer. Its value is dependent, to a great extent, on its user—his knowledge of how to use it and what can be accomplished by its use.

Over the years, many different types of magnifiers have been designed. A glass which is ideal for one job may be entirely inadequate for another.

To select a magnifier, four major considerations must be explored: power, or magnification; working distance; field of view; depth of field. Since all of these considerations are interde-

pendent, a variation in any one will, of necessity, make some change in the others.

Consider Magnification First

A simple formula for determining the magnification of a lens is $\frac{10}{f} = X$ (magnification). In this formula, f stands for focal length. The number 10 stands for 10 inches, the average minimum distance of an object from the "normal" unaided eye. This is based on the practical experience that nearer than 10 inches, objects cannot be seen distinctly by the unaided eye. Using the formula, a lens with a focal length of 5 inches has a magnification of 2 power. Conversely, any lens of 2 power has a focal length of 5 inches. This is a law of physics and there are no exceptions.

Working Distance

Suppose you wish to examine an object, and you cannot bring your magnifier any closer to it than 3 inches. Since magnifiers have a focal length and a working distance approximately the same, it is obvious from the formula for magnification used above, you could not use a 5 X magnifier. It has a working distance of only 2 inches. You must select a lens with a working distance of at least 3 inches. This would mean a 3 X lens.

Field of View

Our third consideration, field of view, is the area seen through the magnifier. The diameter of the field of view of a magnifier is less than its focal length.

We have already found that as the power of a magnifier increases, its working distance decreases. Likewise, as the power increases, the lens diameter also decreases. All of these factors have a direct bearing on the field of view.

As an example, let us suppose we are examining the surface of a large piece of cloth for imperfection of weave. It might take hours to cover the entire surface using a 20 X glass whose field of view is just a little more than ⅜ of an inch. If it is absolutely necessary to study the nature of the imperfections with this high power magnifier, the proper way to go about it would be to use a much lower power glass, marking the questionable areas distinctly, then inspecting those questioned areas with a high power glass.

Depth of Field

Depth of field is the name given to the distance you can move a magnifier toward or away from an object and still have it in good focus. Beyond these limits the object is said to be "out of focus," and the image is not sharp.

Depth of field varies with the power of the lens. It is comparatively great in low power magnifiers, but shrinks, along with working distance, as the power increases.

Movement

Since the lens magnifies speed in the same proportion that it magnifies size, moving objects should be examined only with a low power magnifier.

If there is ever any question in your mind as to which of two powers of magnifiers to choose, favor the lower of the two. Make it a rule, wherever possible, to forsake magnification in favor of greater working distance, greater depth of field, and wide field of view. You will gain better viewing results.

Frog Anatomy Film

Frog Anatomy, a new life science film produced by the Audio-Visual Center, Indiana University, provides an ideal transition from the biology classroom to the laboratory table as it covers the complete process of frog dissection. *Frog Anatomy* provides each student with a front row seat for the dissection demonstration through the eyes of the close-up camera. Designed for use in high school biology or college biology and zoology classes, the 17-minute, 16mm. production is available in color or black and white. Dr. Gerald Gunning, Department of Zoology, Tulane University, is the dissector.

Frog Anatomy shows the dissection of a bullfrog, points out its internal anatomy by systems, and suggests additional investigations. The film opens with an instructor in a classroom demonstrating to his students a method of anaesthetizing a frog. After the frog has become limp, the instructor points out internal structures of the mouth.

Complete Dissection

The frog is pinned to a dissecting tray, and the steps of opening the body cavity and examining the organs are shown. The digestive, urinary, and reproductive (male and female) systems are shown in isolation as well as in the specimen being dissected. The heart and other parts of the circulatory system are examined, as well as the brain, spinal cord, and nerves.

Other possible investigations are touched upon briefly as laboratory students are seen inflating the lungs, examining blood flow in the web of the frog's foot, and dissecting the stomach.

The film concludes with the statement that careful and thoughtful examination of the frog will provide the student with first-hand information concerning its anatomy and that of other vertebrates.

Frog Anatomy fits perfectly into the pattern and purpose of the National Defense Education Act. Two major areas in which it can be used are:

1. As an introduction to laboratory procedures before the students undertake individual work.
2. In systems where laboratory facilities are not available, this film provides an adequate substitute. No substitute can be as valuable as actual experience, but this comes very close.

Prints of *Frog Anatomy* may be purchased from the Audio-Visual Center, Indiana University, Bloomington, Indiana. The price for a color print is $150 and for the black and white, $75. Preview and rental prints are also available.

New Series of Biology Books

A new approach to biology education has been made by a group of American authorities in the biological sciences. Under the editorial leadership

of William D. McElroy and Carl P. Swanson of The Johns Hopkins University, top-flight research scientists have written a series of books designed for biology instruction at the introductory college level. Many of the books, however, are well within the reading ability of the "better than average" high school student.

Eleven short, compact volumes—to be published by Prentice-Hall during 1960 as the *Foundations of Modern Biology*—introduce biology as a unified science based on well-established scientific principles. Closing the gap between current research and teaching, the authors believe that their short, tightly-organized books will convey the basic unity of the biological sciences to the student. Their mission is to present biology, not as a science of classification, but as an application of chemistry, physics and mathematics to the living sciences. These areas hold the greatest challenge for biology in the future, the authors maintain.

Two volumes are now in print, *The Cell*, by Carl P. Swanson, and *Animal Growth and Development*, by Maurice Sussman, Associate Professor of Biology at Brandeis University. The other nine volumes are to appear during the autumn and early winter of 1960. These are:

The Plant Kingdom, by Harold C. Bold
Animal Physiology, by Knut Schmidt-Nielsen
Cellular Physiology and Biochemistry, by William D. McElroy
Animal Diversity, by Earl D. Hanson
The Life of the Green Plant, by Arthur W. Galston
Heredity, by David M. Bonner
Adaptation, by A. M. Srb and Bruce Wallace
Man in Nature, by Marston Bates
Animal Behavior, by V. G. Dethier and Eliot Stellar

Science Teachers Buyer's Guide

Clay-Adams, Inc., a supplier of teaching and laboratory materials for biological and medical science, has published a *Buyer's Guide for Science Teaching*. The 80-page, illustrated guide contains a selection of products in the Clay-Adams line useful in secondary school science programs.

The guide will simplify selection of materials that qualify for purchase under the Title III Program of the National Defense Education Act. Many of the products featured in the guide are similar to those which appear in the Title III purchase guide prepared by the Council of Chief State School Officers. The Clay-Adams Guide is keyed to permit easy identification of these qualifying items.

Copies of the "Buyer's Guide for Science Teaching" may be obtained by writing (on school letterhead) to Clay-Adams, Inc., 141 E. 25th Street, New York 10, N. Y.

Single Solution Developer and Fixer

One of the quieter dreams in photography — persisting for more than 70 years almost completely unknown to the average amateur or professional—is monobath processing of films and papers. The three-bath routine—developer, stop bath, and fixer—has been a standard for so long that suggestions of any different systems are unexpected. A monobath system has now burst out of the blue, not as an experimental gimmick, but as a fully fledged and dependable solution under the name of "Unibath."

Monobath systems of the past have worked, but either poorly, or with such drawbacks as to be merely a technical novelty. They involved extended processing times, high fog level, low resolution, and great loss in film speed. Even a beginner can imagine the draw-

backs to mixing the fixer in with the developer! In many formulas such quantities of caustic chemicals seem to have been introduced (to keep the developing action going in the presence of fixer) that from the lab the cry must have been heard: "Look, Ma! No film!"

What does a monobath process do? Well, you put the film in the tank, the Unibath goes in after it. After four minutes for thin emulsion films, and six for the faster types, you pour it off. Wash the film for five minutes, and that is all. There is no strict temperature control. Room temperature is adequate.

Four minutes or six minutes? The Unibath processes to finality in those times. If you're called to the phone, or have to nip down to the corner and the film stays in for twenty minutes, you've only wasted time. The development stops itself when the film is developed to finality!

Fine Grain Processing

Unibath has phenidone as a developing agent. On medium speed films, grain is just about the same as that with the standard fine grain developer, D.76. Contrast is decided by the contrast of the subject, for this finality development is to a normal gamma—no soot and whitewash negatives result from overdevelopment.

The thin emulsion films proved slightly grainier than Rodinal and similar high resolution developers—quite a standard to meet—but the high resolution characteristics remained. Using 35 mm. Plus X film, the working index of 320 tungsten obtained with other developers was fully sustained with Unibath.

There are Unibaths for microfilm and lithography, for oscillograph recording films and motion picture positives. There is no Unibath for movie reversal processing, nor for color processing.

Unibath isn't a cure-all. It is a tool, for amateurs and professionals, and probably a boon to photofinishing plants, but it won't do quite everything. One situation where Unibath with its finality development might have difficulties is subjects of such extreme contrast that normally considerable exposure and underdevelopment, or even water bath development is required. Even so, the moderate gamma to which Unibath develops the film goes a long way toward meeting this situation in all but the most critical conditions.

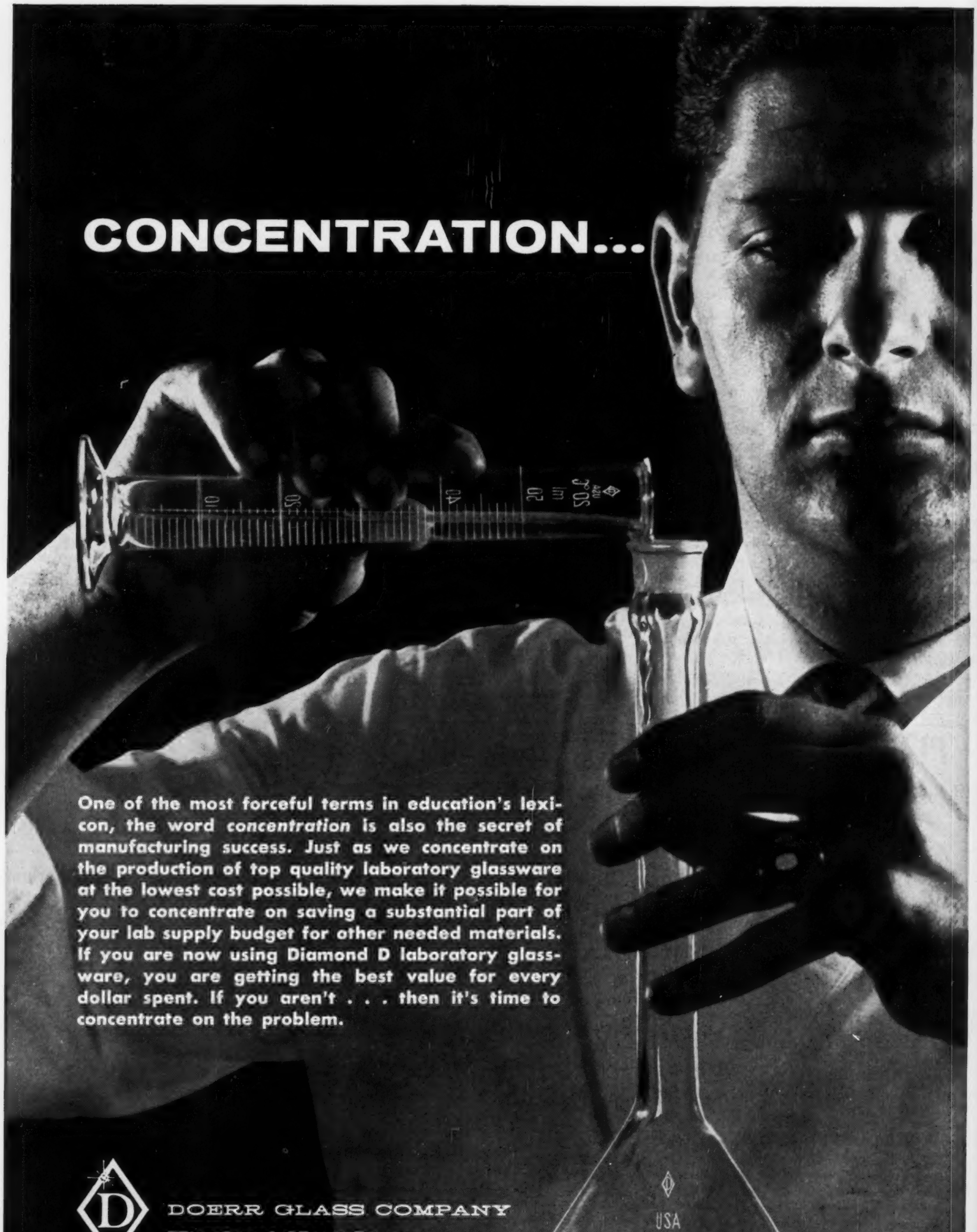
Miniature Water Pump Available

A tiny (2⅜" x 1¾") electric motor and water pump useful for laboratory and project work is now available. Teachers and students may appreciate the unit for its small size, sturdy construction, flexibility, and low cost—$3.95 post paid. The unit pumps a continuous flow of water at the rate of 1 pint per minute at a 12" head. With 2 D-batteries in series, it will pump to 24" high. The pump works in either direction. The pump is distributed by Edmund Scientific Company, Barrington, New Jersey.

Introductory Text on Magnifiers

Bausch & Lomb Incorporated has revised its widely used descriptive catalog covering a complete line of readers and magnifiers. The catalog also contains five pages of introductory optics dealing with magnification, depth of field, field of view, and working distance. Teachers, students, and others, who use magnifiers for any purpose, will find the introductory text material especially valuable. Helpful tips on current working distance, how to determine magnifying power, field of view factors, and the proper magnifier for individual job requirements are discussed in detail. The text should make a useful and different source of material for physics units on optics. It may also be useful to general science classes.

The booklet is available free by writing to Bausch & Lomb Incorporated, Rochester 2, N. Y., specifying Catalog I-103.


CONCENTRATION...
One of the most forceful terms in education's lexicon, the word *concentration* is also the secret of manufacturing success. Just as we concentrate on the production of top quality laboratory glassware at the lowest cost possible, we make it possible for you to concentrate on saving a substantial part of your lab supply budget for other needed materials. If you are now using Diamond D laboratory glassware, you are getting the best value for every dollar spent. If you aren't . . . then it's time to concentrate on the problem.
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